

# **Guidance for Evaluating Soil Vapor Intrusion in the State of New York**

PUBLIC COMMENT DRAFT  
February 2005

Prepared by:



**NEW YORK STATE DEPARTMENT OF HEALTH**  
Center for Environmental Health  
Bureau of Environmental Exposure Investigation

### **Soil Vapor Intrusion Guidance Release History**

February 2005 — Current version (public comment draft)

### **Contact Information**

New York State Department of Health  
Bureau of Environmental Exposure Investigation  
Flanigan Square, Room 300  
547 River Street  
Troy, New York 12180-2216

Email: [BEEI@health.state.ny.us](mailto:BEEI@health.state.ny.us)  
Telephone: 1-800-458-1158, extension 27850

## Preface

This document provides guidance on identifying and addressing current and potential human exposures to contaminated subsurface vapors associated with known or suspected volatile chemical contamination. While vapor intrusion may also occur with "naturally-occurring" subsurface gases (e.g., radon, methane and hydrogen sulfide), the document discusses soil vapor intrusion in terms of environmental contamination only.

The document is organized into five sections:

**Section 1** introduces the concept of soil vapor intrusion, associated human exposure issues, factors affecting soil vapor intrusion, factors affecting indoor air quality, and the general approach to evaluating vapor intrusion;

**Section 2** provides guidance on collecting appropriate and relevant data that can be used to identify current or potential human exposures;

**Section 3** discusses how the investigation data are evaluated, recommends actions based on the evaluation, and presents tools that may be used when determining appropriate actions to address exposures;

**Section 4** provides an overview of soil vapor intrusion mitigation methods and basic requirements pertaining to their selection for use, installation and design, post-mitigation testing, operation, maintenance and monitoring, termination of operation, and annual certification; and

**Section 5** describes outreach techniques commonly used to inform the community about soil vapor intrusion issues.

This page is intentionally blank.

## Table of Contents

	<u>Page</u>
<b>Preface</b> .....	<b>i</b>
 <b>Section 1: Introduction</b> .....	 <b>1</b>
1.1 Soil vapor intrusion .....	1
1.2 Soil vapor intrusion and human exposure .....	1
1.3 Factors affecting soil vapor migration and intrusion .....	2
1.4 Factors affecting indoor air quality .....	4
1.5 General approach to evaluating soil vapor intrusion .....	5
1.6 Applicability of guidance .....	6
 <b>Section 2: Investigation of the Soil Vapor Intrusion Pathway</b> .....	 <b>7</b>
2.1 Sites at which an investigation is necessary .....	7
2.2 Types of samples needed .....	7
2.2.1 Soil vapor .....	7
2.2.2 Sub-slab vapor .....	8
2.2.3 Indoor air .....	8
2.2.4 Outdoor air .....	9
2.3 Phase of a site investigation in which to sample .....	9
2.4 Time of year in which to sample .....	9
2.5 Number of sampling rounds required .....	10
2.6 Sampling locations .....	10
2.6.1 Soil vapor .....	10
2.6.2 Sub-slab vapor .....	12
2.6.3 Indoor air .....	13
2.6.4 Outdoor air .....	14
2.7 Sampling protocols .....	14
2.7.1 Soil vapor .....	14
2.7.2 Sub-slab vapor .....	16
2.7.3 Indoor air .....	18
2.7.4 Outdoor air .....	20
2.7.5 Tracer gas .....	20
2.8 Quality assurance/quality control (QA/QC) .....	22
2.9 Analytical methods .....	23
2.9.1 Subsurface vapor .....	23
2.9.2 Indoor air .....	24
2.9.3 Outdoor air .....	24
2.10 Field laboratories and mobile gas chromatographs (GCs) .....	24
2.11 Surveys and pre-sampling building preparation .....	24
2.11.1 Pre-sampling building inspection and preparation .....	24
2.11.2 Product inventory .....	26
2.12 Environmental and occupational exposures .....	26
2.13 Role of modeling .....	27

	<u>Page</u>
<b>Section 3: Data Evaluation and Recommendations for Action. . . . .</b>	<b>28</b>
3.1 Data quality . . . . .	28
3.2 Overview . . . . .	28
3.2.1 Nature and extent of contamination in all environmental media . . . . .	29
3.2.2 Factors that affect vapor migration and intrusion . . . . .	29
3.2.3 Sources of volatile chemicals . . . . .	29
3.2.4 Background levels of volatile chemicals in air . . . . .	29
3.2.5 Applicable standards, criteria and guidance values . . . . .	33
3.2.6 Completed or proposed remedial actions . . . . .	34
3.2.7 Current and future land uses . . . . .	35
3.3 Sampling results and recommended actions . . . . .	35
3.3.1 Soil vapor . . . . .	35
3.3.2 Sub-slab vapor . . . . .	37
3.3.3 Indoor air . . . . .	38
3.3.4 Outdoor air . . . . .	41
3.4 Decision matrices. . . . .	41
3.4.1 Overview . . . . .	41
3.4.2 Matrices . . . . .	42
3.4.3 Description of recommended actions . . . . .	43
3.5 Emergency response . . . . .	49
3.6 Undeveloped parcels . . . . .	49
 <b>Section 4: Soil Vapor Intrusion Mitigation . . . . .</b>	 <b>50</b>
4.1 Methods of mitigation . . . . .	50
4.1.1 Buildings with a basement slab or slab-on-grade foundation . . . . .	50
4.1.2 Buildings with a crawlspace foundation . . . . .	51
4.1.3 Buildings with dirt floor basements. . . . .	51
4.1.4 Buildings with multiple foundation types . . . . .	52
4.1.5 Undeveloped parcels. . . . .	52
4.1.6 Additional references . . . . .	52
4.2 Design and installation of mitigation systems . . . . .	52
4.2.1 General requirements . . . . .	52
4.2.2 System-specific requirements . . . . .	53
4.2.3 Technical guidance . . . . .	55
4.3 Post-mitigation or confirmation testing . . . . .	56
4.3.1 SSD systems with sealing . . . . .	56
4.3.2 SMD systems with soil vapor retarder . . . . .	58
4.3.3 HVAC modifications . . . . .	58
4.3.4 Crawlspace ventilation and sealing . . . . .	58
4.3.5 SVE systems designed to also mitigate exposures . . . . .	58
4.4 Operation, maintenance and monitoring of mitigation systems . . . . .	59
4.4.1 SSD and SMD systems . . . . .	59
4.4.2 Other mitigation systems . . . . .	60
4.4.3 Non-routine maintenance . . . . .	60
4.5 Termination of mitigation system operations . . . . .	60
4.6 Annual certification and notification requirements . . . . .	61

	<u>Page</u>
<b>Section 5: Community Outreach</b>	<b>62</b>
5.1 Site contact list	62
5.2 Project staff contact sheet	63
5.3 Fact sheets	63
5.4 Public gatherings	64
5.5 Letters transmitting results	65
5.6 Soil vapor intrusion mitigation information	66
5.7 Toll-free "800" numbers	67
5.8 Door-to-door visits	68
5.9 Document repositories	68
5.10 Medical community outreach	68
<b>References</b>	<b>70</b>
 <b>Appendices</b>	
Appendix A: Summary of document revisions	A-1
Appendix B: Indoor air quality questionnaire and building inventory	B-1
Appendix C: Background levels of volatile organic chemicals in air — summary of background databases	C-1
Appendix D: NYSDOH's guidelines for volatile chemicals in air — development overview.	D-1
Appendix E: USEPA's <i>Radon Mitigation Standards (RMS)</i>	E-1
Appendix F: USEPA's <i>Model Standards and Techniques for Control of Radon in New Residential Buildings</i> .	F-1
Appendix G: Community outreach tools — additional information	G-1
G.1 Contact List	G-2
G.2 Fact Sheet	G-7
G.3 Public Meeting	G-13
G.4 Availability Session	G-20
G.5 Toll-free "800" Numbers	G-25
G.6 Door-to-door Visits	G-27
G.7 Document Repository	G-29
Appendix H: NYSDOH fact sheets related to soil vapor intrusion	H-1

## **Tables**

Table 1.1	Environmental factors that affect vapor intrusion . . . . .	3
Table 1.2	Building factors that affect vapor intrusion . . . . .	4
Table 1.3	Alternate sources of volatile chemicals in indoor air . . . . .	5
Table 3.1	Air guideline values derived by the NYSDOH. . . . .	34
Table 3.2	General format of a decision matrix . . . . .	42

## **Figures**

Figure 1.1	Generalized diagram of vapor intrusion in a residential setting from groundwater and subsurface soil sources . . . . .	2
Figure 2.1	Schematic of indoor and outdoor air sampling locations . . . . .	14
Figure 2.2	Schematics of a permanent soil vapor probe and permanent nested soil vapor probes . . . . .	15
Figure 2.3	Schematic of a sub-slab vapor probe . . . . .	17
Figure 2.4	Schematics of tracer gas applications . . . . .	21
Figure 5.1	Manometer indicating the SSD system is operating properly . . . . .	67
Figure 5.2	Example of an illustration showing how a SSD system works . . . . .	67

## **Inserts**

Section 3.2.4	Summary of background levels for selected compounds . . . . .	30
Section 3.4.2	Soil Vapor/Indoor Air Matrix 1 . . . . .	45
Section 3.4.2	Soil Vapor/Indoor Air Matrix 2 . . . . .	47



## Section 1: Introduction

This section introduces the concept of soil vapor intrusion, associated human exposure issues, factors affecting soil vapor intrusion, factors affecting indoor air quality, and the general approach to evaluating vapor intrusion.

### 1.1 Soil vapor intrusion

The phrase "soil vapor intrusion" refers to the process by which volatile chemicals migrate from a subsurface source into the indoor air of buildings. Soil vapor, also referred to as soil gas, is the air found in the pore spaces between soil particles. Primarily because of a difference between interior and exterior pressures, soil vapor can enter a building through cracks or perforations in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation. For example, heating, ventilation or air-conditioning (HVAC) systems and/or the operation of large mechanical appliances (e.g., exhaust fans, dryers, etc.) may create a negative pressure that can draw soil vapor into the building. This intrusion is similar to how radon gas enters buildings from the subsurface.

Soil vapor can become contaminated when chemicals evaporate from subsurface sources. Chemicals that can emit vapors are called "volatile chemicals." Volatile chemicals include volatile organic compounds (VOCs), some semi-volatile organic compounds (SVOCs), and some inorganic substances such as elemental mercury. Subsurface sources of volatile chemicals include the following:

- a. groundwater or soil that contains volatile chemicals;
- b. non-aqueous phase liquid (NAPL);
- c. buried wastes; and
- d. underground storage tanks or drums.

If soil vapor is contaminated and enters a building, indoor air quality may be affected.

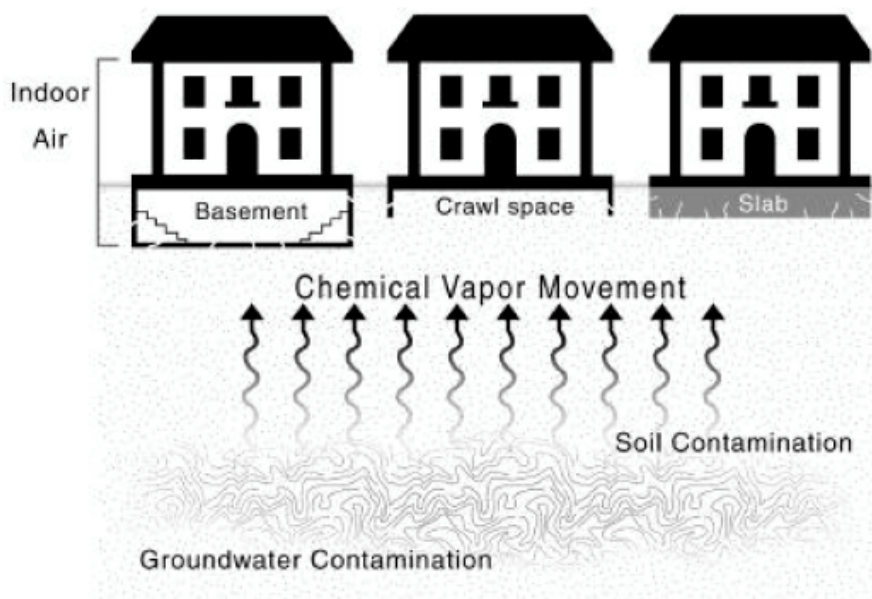
When contaminated vapors are present in the zone directly next to or under the foundation of a building, vapor intrusion is possible. Soil vapor can enter a building whether the building is old or new, or whether it has a basement, a crawl space or is on a slab. This is illustrated in Figure 1.1. However, the subsurface source of the contaminated vapor (e.g., contaminated soil or groundwater) does not need to be directly beneath a structure to contaminate the vapor immediately beneath the building's foundation (as suggested in the figure).

### 1.2 Soil vapor intrusion and human exposure

Humans can be exposed to contaminated soil vapor when the vapor is drawn into the building due to pressure differences [Section 1.1] and mixed with the indoor air. Inhalation is the primary route of exposure, or the manner in which the volatile chemicals, once in the indoor air, actually enter the body.

*Current* exposures exist when vapor intrusion is documented in an occupied building. *Potential* exposures exist when volatile chemicals are present or are accumulating in the vapor phase beneath a building, but have not affected indoor air quality due to current site conditions. Potential exposures also exist when there is a chance that contaminated soil vapors may move beneath existing buildings not currently affected, when indoor air is affected but the building is currently unoccupied, or when there is a chance that new buildings can be built over existing subsurface vapor contamination. Both current and potential exposures must be considered when evaluating soil vapor intrusion at sites.

Exposure to a volatile chemical due to vapor intrusion does not necessarily mean that health effects will occur. Whether or not a person experiences health effects depends on several factors, including the length of exposure (short-term or acute versus long-term or chronic), the amount of exposure (i.e., dose), the frequency of exposure, the toxicity of the volatile chemical and the individual's sensitivity to the chemical.



**Figure 1.1**

Generalized diagram of vapor intrusion in a residential setting from groundwater and subsurface soil sources [Source: USEPA Region 3]

### 1.3 Factors affecting soil vapor migration and intrusion

Predicting the extent of soil vapor contamination from soil or groundwater contamination, as well as the potential for human exposure from soil vapor intrusion into buildings is complicated by factors that can affect soil vapor migration and intrusion. For example, soil vapor contaminant plumes may not mimic groundwater contaminant plumes since different factors affect the migration pattern of each medium. Operation of kitchen vents in restaurants, or of elevators in office buildings, may induce pressure gradients that result in the migration of vapor-phase contaminants away from a groundwater source of vapors and toward these buildings. This is similar to when the pumping of production wells or water supply wells draws contaminated groundwater away from the normal groundwater flow path.

Factors that can affect soil vapor migration and intrusion generally fall into two categories: environmental and building factors. Examples of environmental factors are provided in Table 1.1, and examples of building factors in Table 1.2. These factors are considered when conducting an investigation of the soil vapor intrusion pathway [Section 2] and when evaluating the results [Section 3].

**Table 1.1** Environmental factors that affect vapor intrusion

Environmental Factor	Description
Soil conditions	Generally, dry, coarse-grained soils facilitate the migration of subsurface vapors and wet, fine-grained soils retard migration.
Volatile chemical concentrations	The potential for vapor intrusion generally increases with increasing concentrations of volatile chemicals in groundwater or subsurface soils, as well as with the presence of NAPLs.
Source location	<p>The potential for vapor intrusion generally decreases with increasing distance between the subsurface source of vapor contamination and overlying buildings. For example, the potential for vapor intrusion associated with contaminated groundwater decreases with increasing depth to groundwater.</p> <p>In addition, volatile chemicals dissolved in groundwater may off-gas to the vadose zone from the surface of the water table. If contaminated groundwater is overlain by clean water (upper versus lower aquifer systems or significant downward groundwater gradients), then vapor phase migration or partitioning of the volatile chemicals is unlikely.</p>
Fractures in bedrock and/or tight clay soils	Fractures in bedrock and desiccation fractures in clay can increase the potential for vapor intrusion by facilitating vapor migration (in horizontal and vertical directions) and movement of contaminated groundwater along spaces between fractures.
Surface confining layer	A surface confining layer (e.g., frost layer, pavement or buildings) may temporarily or permanently retard the migration of subsurface vapors to outdoor air, which may result in a localized accumulation of subsurface vapors.
Underground conduits	Underground conduits (e.g., sewer and utility lines, drains or tree roots, septic systems) with highly permeable bedding materials relative to native materials can serve as preferential pathways for vapor migration due to relatively low resistance to flow.
Weather conditions	Wind and barometric pressure changes and thermal differences between indoor air and surrounding soils may induce pressure gradients that affect vapor intrusion.
Biodegradation processes	Depending upon environmental conditions (e.g., soil moisture, oxygen levels, pH, mineral nutrients, organic compounds, and temperature), the presence of appropriate microbial populations, and the degradability of the volatile chemical of concern, biodegradation in the subsurface may reduce the potential for vapor intrusion. For example, readily biodegradable chemicals in soil vapor may not migrate a significant distance from a source area while less degradable chemicals may travel farther.

**Table 1.2** Building factors that affect vapor intrusion

Building Factor	Description
Operation of HVAC systems, fireplaces, and mechanical equipment (e.g., clothes dryers or exhaust fans/vents)	Operation may create a pressure differential between the building or basement air and the surrounding soil that induces or retards the migration of vapor-phase contaminants toward and into the building. Vapor intrusion can be enhanced as the air vented outside is replaced.
Heated building	When buildings are closed up and heated, a difference in temperature between the inside and outdoor air induces a stack effect, venting warm air from higher floors to the outside. Vapor intrusion can be enhanced as the air is replaced in the lower parts of the building.
Air exchange rates	The rate at which outdoor air replenishes indoor air may affect vapor migration into a building as well as the indoor air quality. For example, newer construction is typically designed to limit the exchange of air with the outside environment. This may result in the accumulation of vapors within a building.
Foundation type	Earthen floors and gaps in fieldstone walls may serve as preferential pathways for vapor intrusion.
Foundation integrity	Expansion joints or cold joints, wall cracks, or block wall cavities may serve as preferential pathways for vapor intrusion.
Subsurface features that penetrate the building's foundation	Foundation perforations for subsurface features (e.g., electrical, gas, sewer or water utility pipes, sumps, and drains) may serve as a preferential pathway for vapor intrusion.

#### 1.4 Factors affecting indoor air quality

Chemicals are a part of our everyday life. They are found in the household products we use and in items we bring into our homes. As such, chemicals are found in indoor air of homes not affected by environmental contamination. Examples of alternate sources of volatile chemicals in indoor air are given in Table 1.3.

Similarly, chemicals are also found in outdoor air because of gasoline stations, dry cleaners or other commercial/industrial facilities. Commonly found concentrations of these chemicals in indoor and outdoor air are referred to as "background levels." These levels are determined from the results of samples collected in homes, offices and outdoor areas not known to be affected by external sources of VOCs (for example, a home not known to be near a chemical spill, a hazardous waste site, a dry-cleaner, or a factory). Background sources of volatile chemicals are considered when conducting an investigation of the soil vapor intrusion pathway [Section 2] and when evaluating the results [Section 3].

**Table 1.3** Alternate sources of volatile chemicals in indoor air

Source	Description
Outdoor air	Outdoor sources of pollution can affect indoor air quality due to the exchange of outdoor and indoor air in buildings through natural ventilation, mechanical ventilation or infiltration. Outdoor sources of volatile compounds include automobiles, lawn mowers, oil storage tanks, dry cleaners, gasoline stations, industrial facilities, etc.
Attached or underground garages	Volatile chemicals from sources stored in the garage (e.g., automobiles, lawn mowers, oil storage tanks, gasoline containers, etc.) can affect indoor air quality due to the exchange of air between the garage and indoor space.
Off-gassing	Volatile chemicals may off-gas from building materials (e.g., adhesives or caulk), furnishings (e.g., new carpets or furniture), recently dry-cleaned clothing, or from contaminated groundwater that infiltrates into the basement (e.g., at a sump). Volatile chemicals may also off-gas during the use of contaminated domestic well water (e.g., at a tap or in a shower).
Household products	Household products include, but are not limited to, cleaners, mothballs, cigarette smoke, paints, paint strippers and thinners, air fresheners, lubricants, glues, solvents, pesticides, fuel oil storage, and gasoline storage.
Occupant activities	For example, in non-residential settings, the use of volatile chemicals in industrial or commercial processes or in products used for building maintenance. In residential settings, the use of products containing volatile chemicals for hobbies (e.g., glues, paints, etc.) or home businesses. People working at industrial or commercial facilities where volatile chemicals are used may bring the chemicals into their home on their clothing.
Indoor emissions	These include, but are not limited to, combustion products from gas, oil and wood heating systems that are vented outside improperly, as well as emissions from industrial process equipment and operations.

### 1.5 General approach to evaluating soil vapor intrusion

Since no two sites are exactly alike, the approach to evaluating soil vapor intrusion is dependent upon site-specific conditions. A thorough understanding of the site, including its history of use, characteristics (e.g., geology, geography, identified environmental contamination, etc.) and potentially exposed populations, is used to develop an investigation plan. Existing information is reviewed to determine what data are available and what additional data need to be collected, as well as to guide the investigation. In addition, factors affecting soil vapor migration and intrusion [Section 1.3] and indoor air quality [Section 1.4] are also considered when both conducting an investigation [Section 2] and evaluating the results [Section 3].

This data gathering and review process is repeated until the following questions can be answered:

- [1] Are subsurface vapors contaminated (i.e., soil vapor as defined in Section 1.1, including vapors located immediately beneath the foundation or slab of a building)? If so, what are the nature and extent of contamination? What is/are the source(s) of the contamination?
- [2] What are the current and potential exposures to contaminated subsurface vapors?
- [3] What actions, if any, are needed to prevent or mitigate exposures and to remediate subsurface vapor contamination?

When determining what actions, if any, are necessary to mitigate current or prevent future human exposures, all information known about a site is considered (i.e., a "whole picture" approach is taken) because each site presents its own unique set of circumstances. This information includes, but is not limited to, the following: nature and extent of contamination in all environmental media, factors affecting vapor migration and intrusion, current and future site uses, off-site land uses, presence of alternate sources of volatile chemicals, and completed or proposed remedial actions.

The need for actions to minimize or prevent exposures typically does not preclude the site from being used for a desired purpose or from being developed. If necessary, mitigation systems can be installed at existing buildings or installed during the construction of new buildings. Costs for mitigation systems are often less with new construction because their design and installation can be incorporated during the development project.

## **1.6 Applicability of guidance**

This guidance is applicable anywhere a soil vapor intrusion investigation is warranted in the State of New York.

This document will be updated periodically to remain current because the investigation, evaluation, mitigation and remediation of soil vapor are evolving disciplines. The history of the document's release is provided on the inside of the cover page. In addition, changes to the document are noted in Appendix A. The current version of the document supercedes previous versions. If you are uncertain that you have the current version, please contact the NYSDOH's Bureau of Environmental Exposure Investigation [see contact information on the inside of the cover page].

## Section 2: Investigation of the Soil Vapor Intrusion Pathway

Soil vapor is an environmental medium, like groundwater and soil, that must be characterized during the investigation of a site. This section provides guidance on collecting appropriate and relevant data that can be used to identify current or potential human exposures to contaminated subsurface vapors associated with a site. As discussed in Section 1.5, it is recognized that no two sites are exactly alike and that site-specific conditions may warrant modifying the recommendations herein. Therefore, guidance provided in this section is presented in terms of general steps and strategies that should be applied when approaching an investigation of soil vapor intrusion.

### 2.1 Sites at which an investigation is necessary

The soil vapor intrusion pathway must be investigated at any site with the following:

- a. an existing subsurface source (e.g., on the basis of preliminary environmental sampling) or likely subsurface source (e.g., on the basis of known previous land uses) of volatile chemicals [Section 1.1] and/or groundwater or subsurface soil that contains concentrations of volatile chemicals in excess of their appropriate standard, criteria or guidance concentration; and
- b. existing buildings or the possibility that buildings may be constructed near a subsurface source of volatile chemicals.

### 2.2 Types of samples needed

The following are types of samples that are collected to investigate the soil vapor intrusion pathway:

- a. subsurface vapor samples:
  1. *soil vapor* samples (i.e., soil vapor samples not beneath the foundation or slab of a building) and
  2. *sub-slab vapor* samples (i.e., soil vapor samples immediately beneath the foundation or slab of a building);
- b. indoor air samples; and
- c. outdoor air samples.

The types of samples that should be collected depend upon the specific objective(s) of the sampling, as described below.

#### 2.2.1 Soil vapor

Soil vapor samples are collected to determine whether this environmental medium is contaminated, characterize the nature and extent of contamination, and identify possible sources of the contamination. Soil vapor sampling results are used when evaluating the following:

- a. the potential for *current* human exposures;
- b. the potential for *future* human exposures (e.g., should a building be constructed); and
- c. the effectiveness of measures implemented to remediate contaminated subsurface vapors.

### 2.2.2 Sub-slab vapor

Sub-slab vapor samples are collected to characterize the nature and extent of soil vapor contamination immediately beneath a building with a basement foundation and/or a slab-on-grade. Sub-slab vapor sampling results are used when evaluating the following:

- a. *current* human exposures;
- b. the potential for *future* human exposures (e.g., if the structural integrity of the building changes or the use of the building changes); and
- c. site-specific attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations).

Sub-slab vapor samples are collected after soil vapor characterization and/or other environmental sampling (e.g., soil and groundwater characterization) indicate a need. Sub-slab samples are typically collected concurrently with indoor and outdoor air samples. However, outside of the heating season, sub-slab vapor samples may be collected independently depending on the sampling objective (e.g., characterize the extent of subsurface vapor contamination outside of the heating season to develop a more comprehensive, focused investigation plan for the heating season).

### 2.2.3 Indoor air

Indoor air samples are collected to characterize exposures to air within a building, including those with earthen floors and crawlspaces. Indoor air sampling results are used when evaluating the following:

- a. *current* human exposures;
- b. the potential for *future* exposures (e.g., if a currently vacant building should become occupied); and
- c. site-specific attenuation factors (e.g., the ratio of indoor air to sub-slab vapor concentrations).

Indoor air samples are collected after subsurface vapor characterization and other environmental sampling (e.g., soil and groundwater characterization) indicate a need [Section 3]. When indoor air samples are collected, concurrent sub-slab vapor and outdoor air samples are collected to evaluate the indoor air results appropriately. However, indoor air and outdoor air samples, without sub-slab vapor samples, may be collected when confirming the effectiveness of a mitigation system [Section 4].

In addition, site-specific situations may warrant collecting indoor air samples prior to characterizing subsurface vapors and/or without concurrent sub-slab sampling due to a need to examine immediate inhalation hazards. Examples of such situations may include, but are not limited to, the following:

- a. in response to a spill event when there is a need to qualitatively and/or quantitatively characterize the contamination;
- b. if high readings are obtained in a building when screening with field equipment (e.g., a photoionization detector (PID), an organic vapor analyzer, or an explosimeter) and the source is unknown;
- c. if significant odors are present and the source needs to be characterized; or
- d. if groundwater beneath the building is contaminated, the building is prone to groundwater intrusion or flooding (e.g., sump pit overflows), and subsurface vapor sampling is not feasible.



#### 2.2.4 Outdoor air

Outdoor air samples are collected to characterize site-specific background outdoor air conditions. These samples must be collected simultaneously with indoor air samples. They may also be collected concurrently with soil vapor samples. Outdoor air sampling results are primarily used when evaluating the extent to which outdoor sources may be influencing indoor air quality. They may also be used in the evaluation of soil vapor results (i.e., to identify potential outdoor air interferences associated with the infiltration of outdoor air into the sampling apparatus while the soil vapor sample was collected).

### 2.3 Phase of a site investigation in which to sample

There is no single phase (e.g., preliminary site characterization or remedial investigation) of a site investigation during which samples must be taken to evaluate the soil vapor intrusion pathway. Initiation of investigation activities for this specific purpose should be determined on a site-by-site basis. However, if exposures due to soil vapor intrusion appear likely at any point during the investigation, evaluation of this exposure pathway should not be delayed.

If the locations of likely source areas are reasonably known, sampling earlier during the investigation of a site rather than later is recommended because of the iterative nature of the sampling process [Section 2.5]. However, if current site conditions are not well-defined, then sampling after contamination in other environmental media (e.g., groundwater and soil) has been characterized may be considered. In the latter scenario, groundwater, soil and other site information may be used to guide an investigation of the vapor intrusion pathway, such as selecting locations for subsurface vapor samples based on likely migration pathways and source areas [Sections 2.6.1 and 2.6.2]. At a minimum, depth to groundwater and soil stratigraphy should be identified prior to collecting soil vapor samples.

Sampling may be delayed, with the State's approval, at undeveloped parcels provided

- a. characterization of the parcel is not needed to
  1. address exposures in the surrounding area adequately;
  2. design remedial measures for subsurface vapor contamination; or
  3. monitor or confirm the effectiveness of remedial measures; and
- b. measures are in place that assure the State that the parcel will not be developed without addressing exposure concerns [Section 3.6].

### 2.4 Time of year in which to sample

Sub-slab vapor samples and, unless there is an immediate need for sampling, indoor air samples are typically collected during the heating season because soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. In general, heating systems are expected to be operating routinely from November 15th to March 31st throughout the state. However, this timeframe may vary depending on factors, such as the location of the site (e.g., upstate versus downstate) and the weather conditions for a particular year.

A vapor intrusion investigation may also be conducted outside of the heating season. However, the results may not be used to rule out exposures. For example, results indicating "no further action" or "monitoring required" must be verified during the heating season to ensure these actions are protective during the heating season as well.

## 2.5 Number of sampling rounds required

Investigating a soil vapor intrusion pathway usually requires more than one round of subsurface vapor, indoor air and/or outdoor air sampling, for reasons such as the following:

- a. to characterize the nature and extent of subsurface vapor contamination (similar to the delineation of groundwater contamination) and to address corresponding exposure concerns;
- b. to evaluate fluctuations in concentrations due to
  1. different weather conditions (e.g., seasonal effects),
  2. changes in building conditions (e.g., various operating conditions of a building's HVAC system),
  3. changes in source strength, or
  4. vapor migration or contaminant biodegradation processes (particularly when degradation products may be more toxic than the parent compounds); or
- c. to confirm sampling results or the effectiveness of mitigation or remedial systems.

Overall, as discussed in Section 1.5, successive rounds of sampling are conducted until the following questions can be answered:

- a. Are subsurface vapors contaminated? If so, what are the nature and extent of contamination? What is/are the source(s) of the contamination?
- b. What are the current and potential exposures to contaminated subsurface vapors?
- c. What actions, if any, are needed to prevent or mitigate exposures and to remediate subsurface vapor contamination?

Toward this end, multiple rounds of sampling may be required to characterize the nature and extent of subsurface vapor contamination such that

- a. both potential and current exposures are adequately addressed [Section 2.6];
- b. measures can be designed to remediate subsurface vapor contamination, either directly (e.g., SVE system) or indirectly (e.g., soil excavation or groundwater remediation), given that monitoring and mitigation are considered temporary measures implemented to address exposures related to vapor intrusion until contaminated environmental media are remediated [Section 3.4]; and
- c. the effectiveness of remedial measures can be monitored and confirmed (e.g., endpoint sampling) [Section 4.5].

## 2.6 Sampling locations

### 2.6.1 Soil vapor

If available, existing environmental data (e.g., groundwater and soil data) and site background information should be used to select locations for sampling soil vapor as part of a vapor intrusion investigation. Locations will vary depending upon surface features (e.g., presence or absence of buildings, areas of pavement, or vacant lot) and subsurface characteristics (e.g., soil stratigraphy, buried structures, utility corridors, or clay lenses), as well as the specific purpose of the sampling. Therefore, a figure illustrating proposed sampling locations (with respect to both areal position and depth), actual locations sampled in the field, and relevant on-site and off-site features must be included in all sampling work plans and reports.

Examples of how locations may vary given the specific purpose of the sampling follow. They include general guidelines that should be followed when selecting soil vapor sampling locations:

- a. to evaluate the **potential for current on-site or off-site exposures**, samples should be collected
  1. in the vicinity of a building's foundation [see special sampling consideration at the end of Section 2.6.1 if sampling around a building with no surrounding surface confining layer], as well as between the building's foundation and the source (if known and not located beneath the building),
  2. along the site's perimeter, and
  3. at a depth comparable to the depth of foundation footings (determined on a building-specific or site-specific basis) or at least 1 foot above the water table in areas where the groundwater table is less than 6 feet below grade;
- b. to evaluate the **potential for future exposures if development** on a known or suspected contaminated area on-site or off-site is possible, samples should be collected
  1. in areas with either known or suspected subsurface sources of volatile chemicals, in areas where elevated readings were obtained with field equipment during previous environmental investigations, and in areas of varying isoconcentrations of contamination in the upper groundwater,
  2. in a grid pattern across the area (at an appropriate spacing interval for the size of the area) if information is limited for the area, and
  3. at multiple depths from the suspected subsurface source, or former source, to a depth comparable to the expected depth of foundation footings;
- c. to evaluate the **potential for off-site soil vapor contamination**, samples should be collected
  1. along the site's perimeter,
  2. in areas of potential subsurface sources of vapor contamination (e.g., a groundwater plume that has migrated off-site), and
  3. at a depth comparable to the depth of foundation footings (determined on a site-specific basis) or at least 1 foot above the water table in areas where the groundwater table is less than 6 feet below grade;
- d. to evaluate on-site and off-site **preferential migration pathways** in areas with low permeability soils, samples should be collected
  1. along preferential soil vapor flow paths, such as sewer lines, utility corridors, trenches, pipelines, and other subsurface structures that are likely to be bedded with higher permeability materials, and
  2. at depths corresponding to these subsurface features (will depend on site-specific conditions);
- e. to characterize on-site or off-site **contamination in the vadose zone**, samples should be collected
  1. in areas with either known or suspected sources of volatile chemicals, in areas where elevated readings were obtained with field equipment (e.g., PID) during previous soil and groundwater investigations, and in areas of varying isoconcentrations of contamination in the upper groundwater regime, and
  2. at appropriate depths associated with these areas (will depend on site-specific conditions); and
- f. to investigate the **influence of contaminated groundwater or soil on soil vapor** and to characterize the **vertical profile** of contamination, samples should be

collected from clusters of soil vapor probes at varying depths in the vadose zone [Figure 2.2, Section 2.7.1] and preferably in conjunction with the collection of groundwater or soil samples.

Soil vapor samples collected at depths shallower than 5 feet below grade may be prone to negative bias due to infiltration of outdoor air. Therefore, samples from these depths should be collected only if necessary (based on site-specific conditions), and sampling procedures and results should be reviewed accordingly. The depth of sampling near buildings with slab-on-grade foundations is dependent upon site-specific conditions (e.g., building surrounded by grassy or surface confining layer).

When collecting soil vapor samples around a building with no surrounding surface confining layer (e.g., pavement or sidewalk), samples should be located in native or undisturbed soils away from fill material surrounding the building (approximately 10 feet away from the building) to avoid sampling in an area that may be influenced by the building's operations. For example, operation of HVAC systems, fireplaces, or mechanical equipment (e.g., clothes dryers or exhaust fans/vents) in a building may exacerbate the infiltration of outdoor air into the vadose zone adjacent to the building. As a result, soil vapor samples collected in uncovered areas adjacent to the building may not be representative.

Investigations of soil vapor contamination should proceed outward from known or suspected subsurface sources, as necessary, on an areal basis until potential and current human exposures have been adequately addressed.

#### 2.6.2 Sub-slab vapor

Existing environmental data (e.g., soil vapor, groundwater and soil data), site background information, and building construction details (e.g., basement, slab-on-grade, or multiple types of foundations, HVAC systems, etc.) should be considered when selecting buildings and locations within buildings for sub-slab vapor sampling.

At a minimum, these general guidelines should be followed when selecting buildings to sample for sub-slab vapors:

- a. buildings, including residential dwellings, located above or directly adjacent to known or suspected areas of subsurface volatile chemical contamination should be sampled;
- b. buildings in which positive responses with field equipment (e.g., PID) were obtained, suggesting a completed migration pathway, should be sampled; and
- c. buildings within known or suspected areas of subsurface volatile chemical contamination that are used or occupied by sensitive population groups (e.g., daycare facilities, schools, nursing homes, etc.) should be given special consideration for sampling.

Investigations of sub-slab vapor and/or indoor air contamination should proceed outward from known or suspected sources, as necessary, on an areal basis until potential and current human exposures have been adequately addressed. In cases of widespread vapor contamination and depending upon basis of making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination [Section 3.3.1]), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of sampling approach must be approved by State agency personnel.

Within a building, sub-slab vapor samples should be collected

- a. in a central location away from foundation footings, and
- b. from the soil or aggregate immediately below the basement slab or slab-on-grade.

The number of sub-slab vapor samples required in a building depends upon the number of slabs (e.g., multiple slabs-on-grade in a large warehouse) and foundation types (e.g., combined basement and slab-on-grade in a residence). At least one sub-slab sample should be collected from each representative area.

### 2.6.3 Indoor air

Existing environmental data (e.g., soil vapor, groundwater and soil data), site background information, and building construction details (e.g., basement, slab-on-grade, or multiple types of foundations, HVAC systems, etc.) should be considered when selecting buildings and locations within buildings for indoor air sampling. Indoor air samples are typically collected concurrently with sub-slab vapor and outdoor air samples [Section 2.2.3].

At a minimum, these general guidelines should be followed when selecting buildings to sample for indoor air:

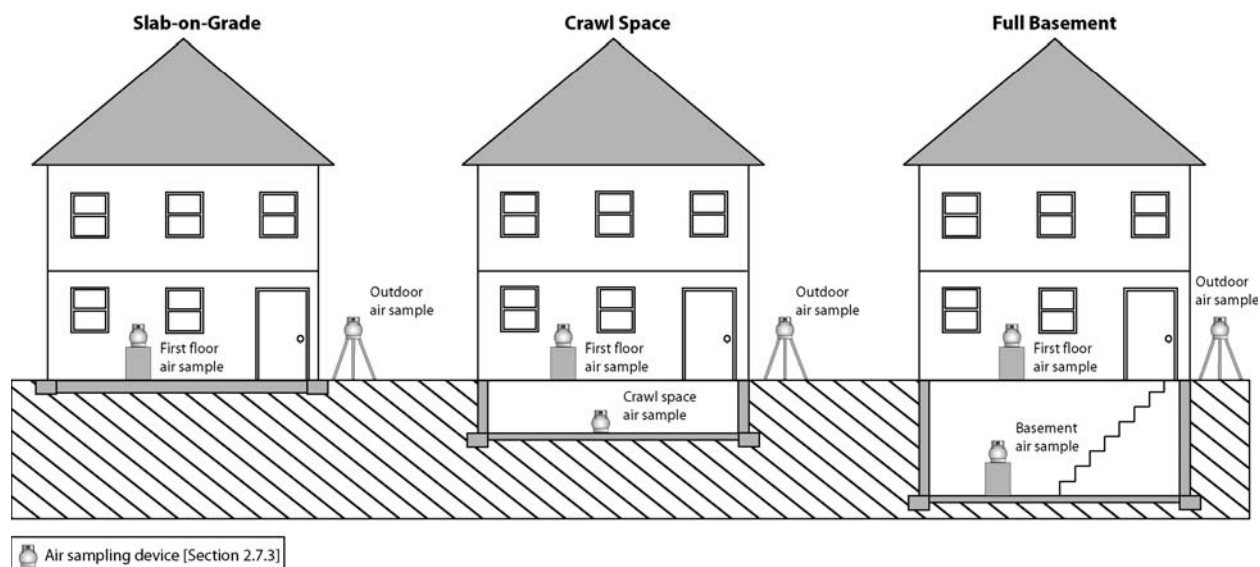
- a. where sub-slab vapor samples were collected without indoor air samples, buildings in which elevated concentrations of contaminants were measured in sub-slab vapor samples should be sampled;
- b. buildings, including residential dwellings, located above or directly adjacent to known or suspected subsurface sources of volatile chemicals or known soil vapor contamination should be sampled;
- c. buildings in which positive responses with field equipment (e.g., PID) were obtained, suggesting a completed migration pathway, should be sampled; and
- d. buildings within known or suspected areas of subsurface volatile chemical contamination that are used or occupied by sensitive population groups (e.g., daycare facilities, schools, nursing homes, etc.) should be given special consideration for sampling.

To characterize contaminant concentration trends and potential exposures, indoor air samples should be collected

- a. from the crawlspace area,
- b. from the basement (where vapor infiltration is suspected or in a central location) at a height approximately three feet above the floor to represent a height at which occupants normally are seated and/or sleep,
- c. from the lowest level living space (in centrally-located, high activity use areas) at a height approximately three feet above the floor to represent a height at which occupants normally are seated and/or sleep, and
- d. if in a commercial setting (e.g., a strip mall), from multiple tenant spaces at a height approximately three feet above the floor to represent a height at which occupants normally are seated.

These locations are illustrated in Figure 2.1.

Investigations of indoor air contamination should proceed outward from known or suspected sources, as necessary, on an areal basis until potential and current human exposures have been addressed. In cases of widespread vapor contamination and depending upon basis of making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of sampling approach must be approved by State agency personnel.



**Figure 2.1**

Schematic of indoor and outdoor air sampling locations

#### 2.6.4 Outdoor air

Typically, an outdoor air sample is collected at each location where an indoor air sample is collected. Outdoor air samples should be collected from a representative upwind location, away from wind obstructions (e.g., trees or bushes), and at a height above the ground to represent breathing zones (3 to 5 feet) [Figure 2.1]. A representative sample is one that is not biased toward obvious sources of volatile chemicals (e.g., automobiles, lawn mowers, oil storage tanks, gasoline stations, industrial facilities, etc.).

### 2.7 Sampling protocols

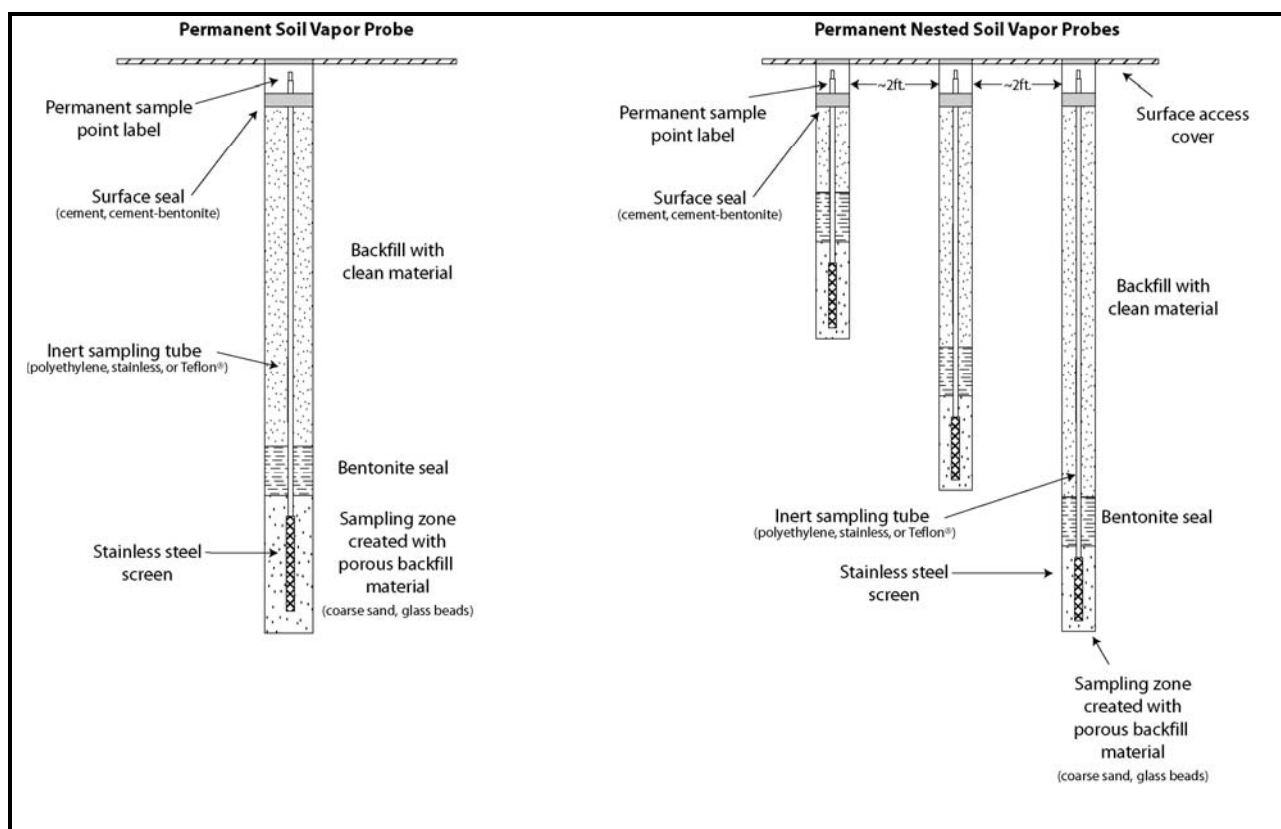
The procedures recommended here may be varied or changed, with the State's approval, depending on site-specific conditions or emerging technologies and methodologies. In all cases, work plans must thoroughly describe the proposed sampling procedure. Similarly, the procedures that were implemented in the field must be documented and included in the final report of the sampling results.

#### 2.7.1 Soil vapor

Soil vapor probe installations [Figure 2.2] may be permanent, semi-permanent or temporary. In general, permanent installations are preferred for data consistency reasons. Soil implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any construction protocol:

- implants should be installed using direct push technology or, if necessary to attain the desired depth, using an auger;
- porous backfill material (e.g., glass beads or coarse sand) should be used to create a sampling zone 1 to 2 feet in length;
- implants should be fitted with inert tubing (e.g., polyethylene, stainless steel, or Teflon®) of the appropriate size (typically 1/8 inch to 1/4 inch diameter) and of laboratory or food grade quality to the surface;

- d. soil vapor probes should be sealed above the sampling zone with a bentonite slurry for a minimum distance of 3 feet to prevent outdoor air infiltration and the remainder of the borehole backfilled with clean material;
- e. for multiple probe depths, the borehole should be grouted with bentonite between probes to create discrete sampling zones; and
- f. for permanent installations, a protective casing should be set around the top of the probe tubing and grouted in place to the top of bentonite to minimize infiltration of water or outdoor air, as well as to prevent accidental damage.



**Figure 2.2**

Schematics of a permanent soil vapor probe and permanent nested soil vapor probes

Soil vapor samples should be collected in the same manner at all locations to minimize possible discrepancies. The following procedures should be included in any sampling protocol:

- a. at least 24 hours after the installation of permanent probes and shortly after the installation of temporary probes, one to three implant volumes (i.e., the volume of the sample probe and tube) must be purged prior to collecting the samples to ensure samples collected are representative;
- b. flow rates for both purging and collecting must not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling;
- c. samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to

minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa® canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory;

- d. sample size depends upon the volume of sample required to achieve minimum reporting limit requirements [Section 2.9]; and
- e. a tracer gas (e.g., helium, butane, or sulfur hexafluoride) must be used when collecting soil vapor samples to verify that adequate sampling techniques are being implemented (i.e., to verify infiltration of outdoor air is not occurring) [Section 2.7.5]. Once verified, continued use of the tracer gas may be reconsidered.

When soil vapor samples are collected, the following actions should be taken to document local conditions during sampling that may influence interpretation of the results:

- a. if sampling near a commercial or industrial building, uses of volatile chemicals during normal operations of the facility should be identified;
- b. outdoor plot sketches should be drawn that include the site, area streets, neighboring commercial or industrial facilities (with estimated distance to the site), outdoor ambient air sample locations (if applicable), and compass orientation (north);
- c. weather conditions (e.g., precipitation, outdoor temperature, barometric pressure, wind speed and direction) should be noted for the past 24 to 48 hours; and
- d. any pertinent observations should be recorded, such as odors and readings from field instrumentation.

The field sampling team must maintain a sample log sheet summarizing the following:

- a. sample identification,
- b. date and time of sample collection,
- c. sampling depth,
- d. identity of samplers,
- e. sampling methods and devices,
- f. purge volumes,
- g. volume of soil vapor extracted,
- h. if canisters used, the vacuum before and after samples collected,
- i. apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and
- j. chain of custody protocols and records used to track samples from sampling point to analysis.

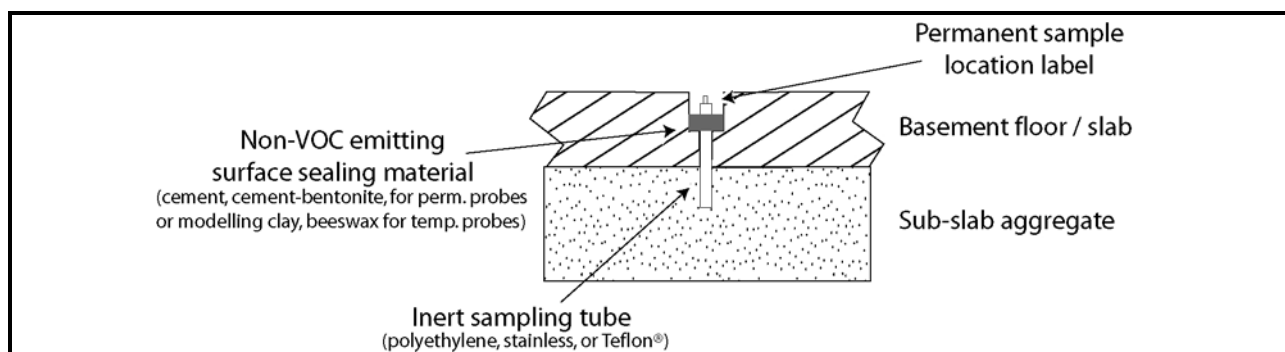
#### 2.7.2 Sub-slab vapor

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. Prior to installation of the sub-slab vapor probe, the building floor should be inspected and any penetrations (cracks, floor drains, utility perforations, sumps, etc.) should be noted and recorded. Probes should be installed at locations where the potential for ambient air infiltration via floor penetrations is minimal.



Sub-slab vapor probe installations [Figure 2.3] may be permanent, semi-permanent or temporary. Sub-slab implants or probes should be constructed in the same manner at all sampling locations to minimize possible discrepancies. The following procedures should be included in any construction protocol:

- permanent recessed probes must be constructed with brass or stainless steel tubing and fittings;
- temporary probes must be constructed with polyethylene or Teflon<sup>®</sup> tubing of laboratory or food grade quality;
- tubing should not extend further than 2 inches into the sub-slab material;
- coarse sand or glass beads should be added to cover about 1 inch of the probe tip for permanent installations; and
- the implant should be sealed to the surface with permagum grout, melted beeswax, putty or other non-VOC-containing and non-shrinking products for temporary installations or cement for permanent installations.



**Figure 2.3**  
Schematic of a sub-slab vapor probe

Sub-slab vapor samples should be collected in the following manner:

- after installation of the probes, one to three volumes (i.e., the volume of the sample probe and tube) must be purged prior to collecting the samples to ensure samples collected are representative;
- flow rates for both purging and collecting must not exceed 0.2 liters per minute to minimize outdoor air infiltration during sampling; and
- samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa<sup>®</sup> canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory;
- sample size depends upon the volume of sample required to achieve minimum reporting limit requirements [Section 2.9], the flow rate, and the sampling duration; and
- ideally, samples should be collected over the same period of time as concurrent indoor and outdoor air samples.

When sub-slab vapor samples are collected, the following actions should be taken to document conditions during sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

- a. if sampling within a commercial or industrial building, uses of volatile chemicals in commercial or industrial processes and/or during building maintenance, should be identified;
- b. the use of heating or air conditioning systems during sampling should be noted;
- c. floor plan sketches should be drawn that include the floor layout with sample locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system air supply and return registers, compass orientation (north), and any other pertinent information should be completed;
- d. if possible, photographs should accompany floor plan sketches;
- e. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), compass orientation (north), footings that create separate foundation sections, and paved areas;
- f. weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported;
- g. smoke tubes or other devices should be used to confirm pressure relationships and air flow patterns, especially between floor levels and between suspected contaminant sources and other areas; and
- h. any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

The field sampling team must maintain a sample log sheet summarizing the following:

- a. sample identification,
- b. date and time of sample collection,
- c. sampling depth,
- d. identity of samplers,
- e. sampling methods and devices,
- f. soil vapor purge volumes,
- g. volume of soil vapor extracted,
- h. if canisters used, vacuum of canisters before and after samples collected,
- i. apparent moisture content (dry, moist, saturated, etc.) of the sampling zone, and
- j. chain of custody protocols and records used to track samples from sampling point to analysis.

### 2.7.3 Indoor air

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance* (February 1, 2005)]

During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. If possible, prior to collecting indoor samples, a pre-sampling inspection [Section 2.11.1] should be performed to evaluate the physical layout and conditions of the building being investigated, to identify conditions that may affect or interfere with the proposed sampling, and to prepare the building for sampling. This process is described in Section 2.11.1.

In general, indoor air samples should be collected in the following manner:

- a. sampling duration should reflect the exposure scenario being evaluated without compromising the detection limit or sample collection flow rate (e.g., an 8 hour sample from a workplace with a single shift versus a 24 hour sample from a workplace with multiple shifts). To ensure that air is representative of the locations sampled and to avoid undue influence from sampling personnel, samples should be collected for at least 1 hour. If the goal of the sampling is to represent average concentrations over longer periods, then longer duration sampling periods may be appropriate. Typically, 24 hour samples are collected from residential settings;
- b. personnel should avoid lingering in the immediate area of the sampling device while samples are being collected;
- c. sample flow rates must conform to the specifications in the sample collection method and, if possible, should be consistent with the flow rates for concurrent outdoor air and sub-slab samples; and
- d. samples must be collected, using conventional sampling methods, in an appropriate container — one which meets the objectives of the sampling (e.g., investigation of areas where low or high concentrations of volatile chemicals are expected; to minimize losses of volatile chemicals that are susceptible to photodegradation), meets the requirements of the sampling and analytical methods (e.g., low flow rate; Summa<sup>®</sup> canisters if analyzing by using EPA Method TO-15), and is certified clean by the laboratory.

At sites with tetrachloroethene contamination, passive air monitors that are specifically analyzed for tetrachloroethene (i.e., "perc badges") are commonly used to collect indoor and outdoor air samples. If site characterization activities indicate that degradation products of tetrachloroethene also represent a vapor intrusion concern, perc badges may be used to indicate the likelihood of vapor intrusion (i.e., by using tetrachloroethene as a surrogate) followed, as needed, by more comprehensive sampling and laboratory analyses to quantify both tetrachloroethene and its degradation products. Perc badge samples ideally should be collected over a twenty-four hour period, but for no less than eight hours.

The following actions should be taken to document conditions during indoor air sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

- a. a product inventory survey must be completed [Section 2.11.2];
- b. the use of heating or air conditioning systems during sampling should be noted;
- c. floor plan sketches should be drawn that include the floor layout with sample locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or subsurface drains and utility perforations through building foundations, HVAC system supply and return registers, compass orientation (north), and any other pertinent information should be completed;
- d. if possible, photographs should accompany floor plan sketches;
- e. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), compass orientation (north), footings that create separate foundation sections, and paved areas;
- f. weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported;
- g. smoke tubes or other devices should be used to confirm pressure relationships and air flow patterns, especially between floor levels and between suspected contaminant sources and other areas; and

- h. any pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation (e.g., vapors via PID, ppbRAE, Jerome Mercury Vapor Analyzer, etc.), should be recorded.

The field sampling team must maintain a sample log sheet summarizing the following:

- a. sample identification,
- b. date and time of sample collection,
- c. sampling height,
- d. identity of samplers,
- e. sampling methods and devices,
- f. depending upon the method, volume of air sampled,
- g. if canisters are used, vacuum of canisters before and after samples collected, and
- h. chain of custody protocols and records used to track samples from sampling point to analysis.

#### 2.7.4 Outdoor air

Outdoor air samples must be collected simultaneously with indoor air samples and may be collected concurrently with subsurface vapor samples. Outdoor air samples must be collected in the same manner as indoor samples [Section 2.7.3].

The following actions should be taken to document conditions during outdoor air sampling and ultimately to aid in the interpretation of the sampling results [Section 3]:

- a. outdoor plot sketches should be drawn that include the building site, area streets, outdoor air sample locations (if applicable), the location of potential interferences (e.g., gasoline stations, factories, lawn movers, etc.), compass orientation (north), footings that create separate foundation sections, and paved areas;
- b. weather conditions (e.g., precipitation, indoor and outdoor temperature, and barometric pressure) and ventilation conditions (e.g., heating system active and windows closed) should be reported; and
- c. any pertinent observations, such as odors, readings from field instrumentation, and significant activities in the vicinity (e.g., operation of heavy equipment or dry cleaners) should be recorded.

#### 2.7.5 Tracer gas

When collecting soil vapor samples as part of a vapor intrusion evaluation, a tracer gas serves as a quality assurance/quality control device to verify the integrity of the soil vapor probe seal. Without the use of a tracer, there is no way to verify that a soil vapor sample has not been diluted by surface air.

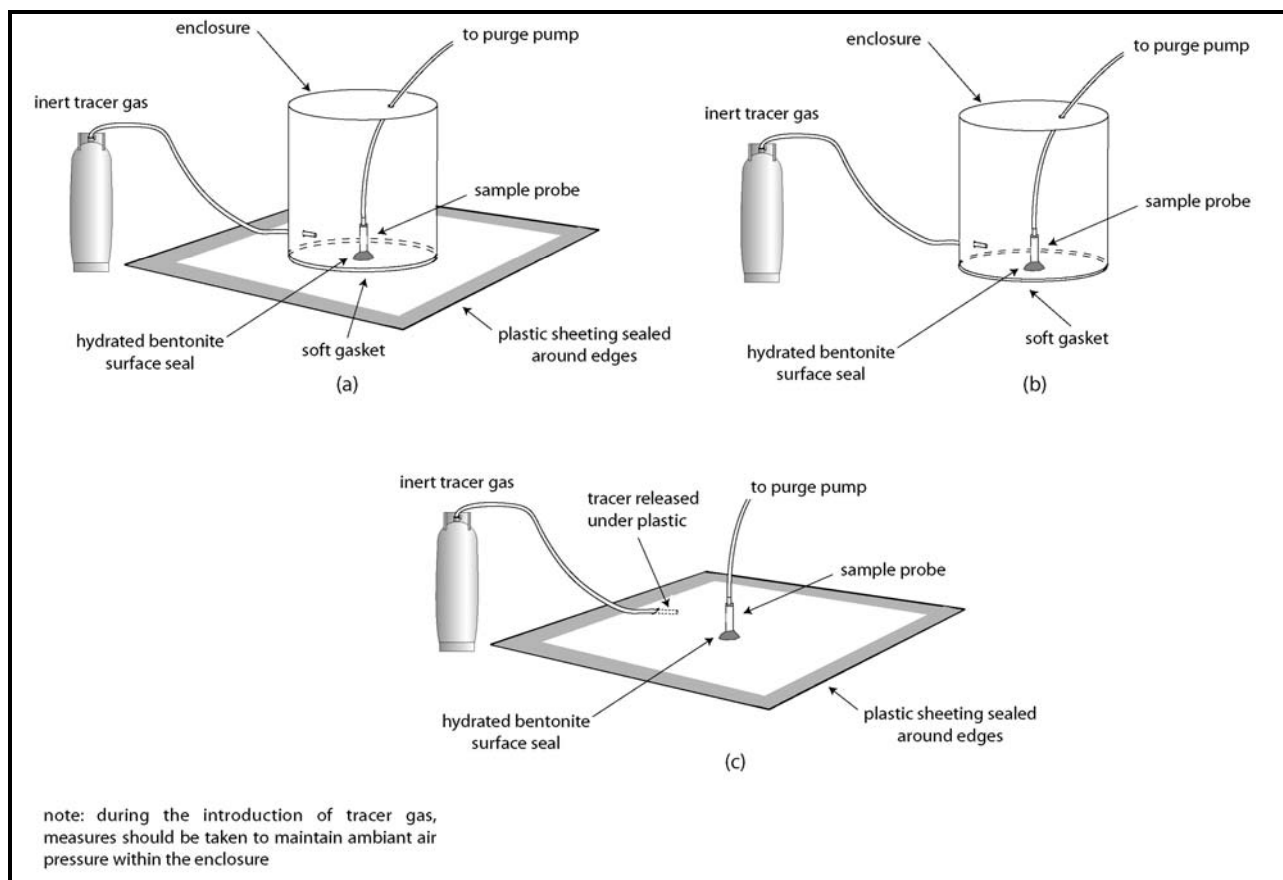
Depending on the nature of the contaminants of concern, a number of different compounds can be used as a tracer. Typically, sulfur hexafluoride (SF<sub>6</sub>) or helium are used as tracers because they are readily available, have low toxicity, and can be monitored with portable measurement devices. Butane and propane (or other gases) could also be used as a tracer in some situations. The protocol for using a tracer gas is straightforward: simply enrich the atmosphere in the immediate vicinity of the area where the probe intersects the ground surface with the tracer gas, and measure a vapor sample from the probe for the presence of high concentrations (> 20%) of the tracer. A cardboard box, a plastic pail, or even a garbage bag can serve to keep the tracer gas in contact with the probe during the testing.

There are two basic approaches to testing for the tracer gas:

1. include the tracer gas in the list of target analytes reported by the laboratory; or
2. use a portable monitoring device to analyze a sample of soil vapor for the tracer gas prior to and after sampling for the compounds of concern. (Note that the tracer gas samples can be collected via syringe, Tedlar bag etc. They need not be collected in Summa<sup>®</sup> canisters or minicans.)

The advantage of the second approach is that the real time tracer sampling results can be used to confirm the integrity of the probe seals prior to formal sample collection.

Figure 2.4 depicts common methods for using tracer gas. In each of the examples, a, b and c, the tracer gas is released in the enclosure prior to initially purging the sample point. Care should be taken to avoid excessive purging prior to sample collection. Care should also be taken to prevent pressure build-up in the enclosure during introduction of the tracer gas. Inspection of the installed sample probe, specifically noting the integrity of the surface seal and the porosity of the soil in which the probe is installed, will help to determine the tracer gas setup. Figure 2.4a may be most effective at preventing tracer gas infiltration, however, it may not be required in some situations depending on site-specific conditions. Figures 2.4b and 2.4c may be sufficient for probes installed in tight soils with well-constructed surface seals. In all cases, the same tracer gas application should be used for all probes at any given site.



**Figure 2.4**  
Schematics of tracer gas applications

Because minor leakage around the probe seal should not materially affect the usability of the soil vapor sampling results, the mere presence of the tracer gas in the sample should not be a cause for alarm. Consequently, portable field monitoring devices with detection limits in the low ppm range are more than adequate for screening samples for the tracer. If high concentrations (> 20%) of tracer gas are observed in a sample, the probe seal should be enhanced to reduce the infiltration of ambient air.

During the initial stages of a soil vapor sampling program, tracer gas samples should be collected at each of the sampling probes. If the results of the initial samples indicate that the probe seals are adequate, the project manager can consider reducing the number of locations at which tracer gas samples are employed. At a minimum, at least 10% of the subsequent samples should be supported with tracer gas analyses. When using permanent soil vapor probes as part of a long-term monitoring program, annual testing of the probe integrity is recommended.

## 2.8 Quality assurance/quality control (QA/QC)

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance* (February 1, 2005)]

Extreme care should be taken during all aspects of sample collection to ensure that sampling error is minimized and high quality data are obtained. The sampling team members should avoid actions (e.g., fueling vehicles, using permanent marking pens, and wearing freshly dry-cleaned clothing or personal fragrances) which can cause sample interference in the field. Appropriate QA/QC protocols must be followed for sample collection and laboratory analysis, such as use of certified clean sample devices, meeting sample holding times and temperatures, sample accession, chain of custody, etc. Samples should be delivered to the analytical laboratory as soon as possible after collection. In addition, laboratory accession procedures must be followed including field documentation (sample collection information and locations), chain of custody, field blanks, field sample duplicates and laboratory duplicates, as appropriate.

Some methods require collecting samples in duplicate (e.g., indoor air sampling using passive sampling devices for tetrachloroethene) to assess errors. Duplicate and/or split samples should be collected in accordance with the requirements of the sampling and analytical methods being implemented.

For certain regulatory programs, a Data Usability Summary Report (DUSR) may be required to determine whether or not the data, as presented, meets the site or project specific criteria for data quality and data use. This requirement may dictate the level of QC and the category of data deliverable to request from the laboratory. Guidance on preparing a DUSR is available by contacting the NYSDEC's Division of Environmental Remediation.

New York State Public Health Law requires laboratories analyzing environmental samples collected from within New York State to have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. If ELAP certification is not currently required for an analyte (e.g., trichloroethene), the analysis should be performed by a laboratory that has ELAP certification for similar compounds in air and uses analytical methods with detection limits similar to background (e.g., tetrachloroethene via EPA Method TO-15). Questions about a laboratory's current certification status should be directed to an ELAP representative at 518-485-5570 or by email at [elap@health.state.ny.us](mailto:elap@health.state.ny.us).

The work plan must state that all samples that will be used to make decisions on appropriate actions to address exposures and environmental contamination will be analyzed

by an ELAP-certified laboratory. If known, the name of the laboratory should also be provided. Similarly, the name of the laboratory that was used must be included in the report of the sampling results. For samples collected and tested in the field for screening purposes by using field testing technology, the qualifications of the field technician must be documented in the work plan.

## 2.9 Analytical methods

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

Proposed analytical procedures must be identified in work plans. Similarly, the analytical procedures that were used and corresponding reporting limits must be identified when reporting the sampling results. As described in Section 3, sampling results for volatile chemicals are compared to background concentrations. Therefore, samples must be analyzed by methods that can achieve minimum reporting limits (typically, 1 microgram per cubic meter (mcg/m<sup>3</sup>) or less) to allow for comparison of the results to background levels. Commonly used methods include United State Environmental Protection Agency (EPA) Method TO-15 for volatile organic compounds (e.g., samples from evacuated canisters) and NYSDOH Method 311-9 for tetrachloroethene (e.g., samples from perc badges). The laboratory should verify that they are capable of detecting the appropriate analytes and can report them at the appropriate reporting limit.

### 2.9.1 Subsurface vapor

Soil vapor and sub-slab vapor samples should be analyzed for a wide range of volatile chemicals during the first round of sampling (at a minimum). This is analogous to analyzing groundwater samples for a suite of compounds (e.g., EPA's target analyte list/target compound list (TAL/TCL) chemicals) during the initial rounds of site characterization. Based on the initial sampling results, development of a site-specific analyte list may be considered for analysis of subsequent soil vapor and sub-slab vapor samples.

If a site-specific analyte list is developed, it should include the following:

- volatile chemicals which have been previously detected in environmental media (e.g., soil, groundwater and air) at the site;
- volatile chemicals which are known or demonstrated constituents of the contamination in question (e.g., petroleum products or tars from former manufactured gas plants); and
- expected degradation products of the chemicals mentioned in a or b.

The following are examples of indicator compounds that have been used at sites given the nature of the contamination or type of site:

- gasoline: benzene, toluene, ethylbenzene, xylenes, trimethylbenzene isomers, individual C-4 to C-8 aliphatics (e.g., hexane, cyclohexane, dimethylpentane, 2,2,4-trimethylpentane, etc.), and appropriate oxygenate additives (e.g., methyl-*tert*-butyl ether, ethanol, etc.);
- middle distillate fuels (#2 fuel oil, diesel and kerosene): n-nonane, n-decane, n-undecane, n-dodecane, trimethylbenzene isomers, tetramethylbenzene isomers, naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene;
- manufactured gas plant sites: trimethylbenzene isomers, tetramethylbenzene isomers, thiopenes, indene, indane, and naphthalene;
- natural gas: propane, propene, butane, iso-butane, methylbutane, and n-pentane with lower levels of higher molecular weight aliphatic, olefinic, and some aromatic compounds; and

- e. solvent-using industries: the solvent and its expected degradation products (e.g., tetrachloroethene, trichloroethene, dichloroethene(s), and vinyl chloride).

### 2.9.2 Indoor air

Indoor and outdoor air samples should be analyzed for a wide range of volatile chemicals if there are no existing data for subsurface vapors. If the need for indoor air sampling is based on the levels of volatile chemicals in subsurface vapors, analysis of indoor air samples specifically for those volatile chemicals may be considered.

### 2.9.3 Outdoor air

Outdoor air samples should be analyzed in a manner consistent with corresponding indoor air samples.

## 2.10 **Field laboratories and mobile gas chromatographs (GCs)**

Use of field laboratories and mobile GCs as screening tools when collecting soil vapor samples may be considered on a site-specific basis. However, without ELAP certification, screening tools such as these are not acceptable when collecting sub-slab vapor, indoor air and outdoor air samples for the purpose of evaluating exposures related to soil vapor intrusion. ELAP certification for a particular laboratory does not indicate mobile laboratory or GC certification. Mobile laboratories and GCs have specific certification requirements through ELAP. Questions regarding a mobile laboratory's certification should be directed to the laboratory itself.

## 2.11 **Surveys and pre-sampling building preparation**

[Reference: NYSDOH's *Indoor Air Sampling & Analysis Guidance (February 1, 2005)*]

### 2.11.1 Pre-sampling building inspection and preparation

A pre-sampling inspection should be performed prior to each sampling event to identify and minimize conditions that may interfere with the proposed testing. The inspection should evaluate the type of structure, floor layout, air flows and physical conditions of the building(s) being studied. This information, along with information on sources of potential indoor air contamination [Section 2.11.2], should be identified on a building inventory form. An example of a building inventory form is given in Appendix B. Items to be included in the building inventory include the following:

- a. construction characteristics, including foundation cracks and utility penetrations or other openings that may serve as preferential pathways for vapor intrusion;
- b. presence of an attached garage;
- c. recent renovations or maintenance to the building (e.g., fresh paint, new carpet or furniture);
- d. mechanical equipment that can affect pressure gradients (e.g., heating systems, clothes dryers or exhaust fans);
- e. use or storage of petroleum products (e.g., fuel containers, gasoline operated equipment and unvented kerosene heaters); and
- f. recent use of petroleum-based finishes or products containing volatile chemicals.

Each room on the floor of the building being tested and on lower floors, if possible, should be inspected. This is important because even products stored in another area of a building can affect the air of the room being tested.



The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building.

Potential interference from products or activities releasing volatile chemicals may need to be controlled. Removing the source from the indoor environment prior to testing is the most effective means of reducing interference. Ensuring that containers are tightly sealed may be acceptable. When testing for volatile organic compounds, containers should be tested with portable vapor monitoring equipment to determine whether compounds are leaking. The inability to eliminate potential interference may be justification for not testing, especially when testing for similar compounds at low levels. The investigator should consider the possibility that chemicals may adsorb onto porous materials and may take time to dissipate.

In some cases, the goal of the testing is to evaluate the impact from products used or stored in the building (e.g., pesticide misapplications, school renovation projects). If the goal of the testing is to determine whether products are an indoor volatile chemical contaminant source, the removing these sources does not apply.

Once interfering conditions are corrected (if applicable), ventilation may be needed prior to sampling to eliminate residual contamination in the indoor air. If ventilation is appropriate, it should be completed 24 hours or more prior to the scheduled sampling time. Where applicable, ventilation can be accomplished by operating the building's HVAC system to maximize outside air intake. Opening windows and doors, and operating exhaust fans may also help or may be needed if the building has no HVAC system.

Air samples are sometimes designed to represent typical exposure in a mechanically ventilated building and the operation of HVAC systems during sampling should be noted on the building inventory form [Appendix B]. In general, the building's HVAC system should be operating under normal conditions. Unnecessary building ventilation should be avoided within 24 hours prior to and during sampling. During colder months, heating systems should be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time.

Depending upon the goal of the indoor air sampling, some situations may warrant deviation from the above protocol regarding building ventilation. In such cases, building conditions and sampling efforts should be understood and noted within the framework and scope of the investigation.

To avoid potential interferences and dilution effects, every effort should be made to avoid the following for 24 hours prior to sampling:

- a. opening any windows, fireplace dampers, openings or vents;
- b. operating ventilation fans unless special arrangements are made;
- c. smoking in the building;
- d. painting;
- e. using a wood stove, fireplace or other auxiliary heating equipment (e.g., kerosene heater);
- f. operating or storing automobile in an attached garage;
- g. allowing containers of gasoline or oil to remain within the house or garage area, except for fuel oil tanks;

- h. cleaning, waxing or polishing furniture, floors or other woodwork with petroleum- or oil-based products;
- i. using air fresheners, scented candles or odor eliminators;
- j. engaging in any hobbies that use materials containing volatile chemicals;
- k. using cosmetics including hairspray, nail polish, nail polish removers, perfume/cologne, etc.;
- l. lawn mowing, paving with asphalt, or snow blowing;
- m. applying pesticides; and
- n. using building repair or maintenance products, such as caulk or roofing tar.

#### 2.11.2 Product inventory

The primary objective of the product inventory is to identify potential air sampling interference by characterizing the occurrence and use of chemicals and products throughout the building, keeping in mind the goal of the investigation and site-specific contaminants of concern. For example, it is not necessary to provide detailed information for each individual container of like items. However, it is necessary to indicate that "20 bottles of perfume" or "12 cans of latex paint" were present with containers in good condition. This information is used to help formulate an indoor environment profile.

An inventory should be provided for each room on the floor of the building being tested and on lower floors, if possible. This is important because even products stored in another area of a building can affect the air of the room being tested.

The presence and description of odors (e.g., solvent, moldy) and portable vapor monitoring equipment readings (e.g., PIDs, ppbRAE, Jerome Mercury Vapor Analyzer, etc.) should be noted and used to help evaluate potential sources. This includes taking readings near products stored or used in the building. Products in buildings should be inventoried every time air is tested to provide an accurate assessment of the potential contribution of volatile chemicals. If available, chemical ingredients of interest (e.g., analyte list) should be recorded for each product. If the ingredients are not listed on the label, record the product's exact and full name, and the manufacturer's name, address and telephone number, if available. In some cases, material Safety Data Sheets may be useful for identifying confounding sources of volatile chemicals in air. Adequately documented photographs of the products and their labeled ingredients can supplement the inventory and facilitate recording the information.

#### **2.12 Environmental and occupational exposures**

This section of the guidance document, Section 2, focuses on investigating current and potential human exposures to contaminated subsurface vapors associated with a site (i.e., environmental exposures). All of the above considerations must be taken into account when investigating exposures related to soil vapor intrusion in buildings used for residential purposes. They must also be considered when investigating commercial or industrial buildings unless it is demonstrated that exposures are occupational rather than environmental.

Occupational exposures are subject to investigation and evaluation procedures recommended by occupational agencies, such as the Occupational Safety and Health Administration (OSHA), the National Institute for Occupational Safety and Health (NIOSH), or the American Conference of Governmental Industrial Hygienists (ACGIH). Occupational exposures are exposures that result from current commercial or industrial processes within the building.

### **2.13 Role of modeling**

At sites where there is a potential for human exposures to subsurface contamination due to soil vapor intrusion (as described in Section 2.1), use of modeling as the sole means of evaluating potential exposures is not acceptable. Conclusions drawn from modeling must be verified with actual field data. For example, if modeling results indicate indoor air concentrations are predicted to be below applicable guidelines or levels of concern, indoor air and/or sub-slab vapor sampling would be required to verify a conclusion that mitigation actions are not needed.

Modeling may, however, be used as a tool in the evaluation process. Examples of situations in which modeling may be used as a tool include, but are not limited to, the following:

- a. to help identify potential migration pathways on the basis of site-specific conditions;
- b. to estimate potential exposures when field samples cannot be collected (e.g., access to collect the samples is denied or buildings have not yet been constructed over the subsurface contamination);
- c. to estimate potential past exposures where limited field data were collected (e.g., soil vapor sampling results available without indoor air sampling results); and
- d. to identify a preferred order for sampling buildings by predicting expected indoor air concentrations within each of the buildings if there are numerous buildings overlying the subsurface contamination.

Use of any model at a site should be discussed with the agencies prior to the model's development. If a model is used, it should incorporate site-specific parameters (e.g., attenuation factors, soil conditions, concentrations of volatile chemicals, depth to subsurface source, characteristics of subsurface source, and foundation slab thickness) as much as possible. Furthermore, both the limitations of the model (e.g., exclusion of preferential migration pathways) and the sensitivity of the variables in the model must be understood and identified with the modeling results.

### **Section 3: Data Evaluation and Recommendations for Action**

Section 3 describes the process by which data obtained during the investigation are evaluated. The goals of the evaluation are as follows:

- a. to determine what volatile chemicals, if any, are present in the investigated media;
- b. to identify the likely cause(s) of their presence; and
- c. to identify completed and potential human exposures and the need for actions to address exposures.

Also discussed are actions typically recommended based on the evaluation. Actions to remediate the source(s) of soil vapor contamination, such as soil excavation or air-sparge/soil vapor extraction systems, are beyond the scope of this guidance and are not included.

#### **3.1 Data quality**

Before the data are evaluated, their representativeness and reliability must be verified. To assess analytical errors and the usability of the data, a qualified person should review the analytical data package and all associated QA/QC information to make sure that

- a. the data package is complete;
- b. holding times have been met;
- c. the QC data fall within the protocol required limits and specifications;
- d. the data have been generated using established and agreed upon analytical protocols;
- e. the raw data confirm the results provided in the data summary sheets and QC verification forms; and
- f. correct data qualifiers have been used.

For sites in a regulatory program (e.g., State Superfund), a DUSR [Section 2.7] (or RCRA equivalent) should be generated in accordance with NYSDEC guidance and be submitted for regulatory review and approval.

If the investigation was not completed in accordance with the guidelines set forth in Section 2, additional investigation may be needed to either replace or complement the existing data. For example, product inventories [Section 2.10.2] filled out incompletely or incorrectly may need to be redone so that likely sources of volatile chemicals in the indoor air can be identified and appropriate actions to mitigate exposures can be recommended.

#### **3.2 Overview**

The results of individual soil vapor, sub-slab vapor, indoor air and outdoor air samples are not reviewed in isolation. Rather, they are evaluated with the consideration of several additional factors, which include the following:

- a. the nature and extent of contamination in *all* environmental media;
- b. factors that affect vapor migration and intrusion;
- c. completed or proposed remedial actions;
- d. sources of volatile chemicals;
- e. background levels of volatile chemicals in air;
- f. applicable standards, criteria and guidance values; and
- g. current and future land uses.

These factors are described in detail in this subsection.

### 3.2.1 Nature and extent of contamination in all environmental media

The type of volatile chemicals present and the extent of contamination in all environmental media — including soil, groundwater, subsurface vapors, indoor air and outdoor air — is considered when evaluating the data. Trends in environmental data (e.g., groundwater monitoring results show concentrations of volatile chemicals are decreasing) are also considered. This information is used to identify possible sources of contamination and migration pathways, as well as to recommend appropriate actions to address exposures.

### 3.2.2 Factors that affect vapor migration and intrusion

As discussed in Section 1.3, there are numerous site-specific environmental factors [Table 1.1] and building factors [Table 1.2] that can affect soil vapor migration and intrusion. This information is used to identify possible sources of contamination and migration pathways, as well as to recommend appropriate actions to address exposures.

### 3.2.3 Sources of volatile chemicals

An understanding of the likely sources of the chemicals is crucial for determining appropriate actions to address exposure, as well as identifying the parties responsible for implementing the actions. Volatile chemicals that are not site-related may be present in the investigated media for reasons such as the following:

- a. *subsurface vapors* — misuse, misapplication, or improper disposal of the chemicals to the subsurface, unidentified subsurface sources of vapor contamination, presence of septic systems (where products, such as cleaning agents or degreasers, may be disposed), and infiltration into the subsurface from a building under positive pressure in which the chemicals are heavily used (i.e., reverse process from soil vapor intrusion);
- b. *indoor air* — use and storage of volatile chemical-containing products, off-gassing from building materials or new furnishings, use of contaminated groundwater during private well usage, and infiltration of outdoor air containing volatile chemicals; and
- c. *outdoor air* — emissions from automobiles, lawn mowers, oil storage tanks, gasoline stations, and dry cleaners or other commercial/industrial facilities [Table 1.3].

Site-related chemicals may also be present for these same reasons.

### 3.2.4 Background levels of volatile chemicals in air

Chemicals are part of our everyday life [Section 3.2.3]. As such, they are found in the indoor air of buildings not affected by environmental contamination. They are also found in the outdoor air. Background levels are determined from the results of samples collected in homes, offices and outdoor areas. Several studies provide background levels and the criteria used to select sampling locations define background for that study. Generally, sampling locations are not near known sources of volatile chemicals (for example, a home not near a chemical spill, a hazardous waste site, a dry-cleaner, or a factory). The criteria for sampling indoor air may require checking containers of volatile chemicals to make sure they are tightly closed or removing those products before samples are taken. Depending on the criteria for site selection and sampling conditions, background levels may not be the same as what would be expected if indoor air were sampled in randomly selected homes. Background levels are used as screening tools when determining appropriate actions to address exposure. They are not standards and are not meant to be interpreted as such.

Several studies have been conducted, both nationally and in the State of New York, to determine indoor and outdoor air background levels in a variety of settings (e.g., residential or commercial buildings). Databases that are used when evaluating indoor and outdoor air

data are introduced below. A more detailed description of each database is provided in Appendix C.

- a. *NYSDOH: Study of Volatile Organic Chemicals in Air of Fuel Oil Heated Homes*  
Results of indoor and outdoor air samples collected from 104 single-family fuel oil heated homes throughout New York State. Samples collected in evacuated canisters and analyzed for 69 aromatic, aliphatic, and halogenated hydrocarbons, and ketones by modified EPA Method TO-15. Limitations: only fuel oil heated homes, homes not completely random, and five boroughs of New York City were excluded.
- b. *USEPA: Building Assessment and Survey Evaluation (BASE) Database*  
Study of measured concentrations of volatile organic compounds from 100 randomly selected public and commercial office buildings. Samples collected by evacuated canisters and/or tube methodologies. Limitations: only represents office settings, two methodologies used for sampling, and analysis that are not completely overlapping and do not show agreement in results in some cases.
- c. *NYSDOH: Control Home Database*  
Indoor and outdoor air samples compiled from 53 residences in New York State that were considered "control Homes" with neighborhood, construction, and occupancy similar to potentially impacted homes that were being investigated at the time. Limitations: multiple methodologies for sampling and analysis, small sample size, and varying detection limits often higher than current background levels.
- d. *USEPA: National Ambient Volatile Organic Compounds (VOCs) Data Base Update*  
Published and unpublished air data compiled by the USEPA in 1988. The document includes data from studies between 1970 to 1987. The database covers more than 300 chemicals in indoor and outdoor settings. Limitations: data are compiled from numerous studies with limitations on selection or screening criteria, data are 20-35 years old, indoor air data include both residential and office spaces, sample size for some analytes is very small (less than 10). Outdoor air data include rural, suburban, urban, source dominated and remote locations.

Each database offers useful information and has its own set of limitations, which must be considered during its use. The database or combination of databases, that best represents site-specific and building-specific conditions should be used as a basis of comparison. The additional information that is provided for each database in Appendix C should be considered when making this determination.

A table is included in this section that summarizes background levels from the databases for many of the compounds commonly detected. Data from the background studies exhibit a lognormal distribution typical of environmental data. For many analytes, means differ among the databases dramatically because of one or two high values. To characterize the data, percentiles were calculated in all datasets and include at least the 25<sup>th</sup>, 50<sup>th</sup> and 75<sup>th</sup> percentile values. The 25% to 75% ranges provided in the table represent the middle half of the results and are labeled as background. However, the NYSDOH recognizes that statistically 25% of the values are below this range and 25% are above this range. The NYSDOH generally uses the NYSDOH Fuel Oil Study data and the EPA BASE data when evaluating indoor air in residences and office or commercial buildings, respectively. There may be instances when the older NYSDOH and EPA databases may be used. State agency personnel must approve use of other databases when evaluating data and selecting actions to address exposures.

## Summary of Background Levels<sup>1</sup> for Selected Compounds

### All Results Are Micrograms Per Cubic Meter (mcg/m<sup>3</sup>)

Compound	NYSDOH Study <sup>2</sup>		EPA BASE Data <sup>3</sup>		NYSDOH Database <sup>4</sup>		EPA Database <sup>5</sup>	
	Homes in NYS 1997 - 2003		Offices 1994 - 1998		Homes in NYS 1989 - 1996		Homes & Offices 1970 - 1988	
	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor	Indoor	Outdoor
1,1,1-trichloroethane	<0.25 - 1.4	<0.25 - 0.38	2.6 - 11	<0.6 - 1.7	<5.0 - 6.7	<2.0 - 2.8	3.0 - 30	0.7 - 3.3
1,1,2,2-tetrachloroethane	<0.25	<0.25	NA	NA	<1.5	<1.5	ND	ND - 0.06
1,1,2-trichloroethane	<0.25	<0.25	<1.3	<12	<1.0	<1.0	NA	ND - 0.14
1,1,-dichloroethane	<0.25	<0.25	<0.5	<0.4	<1.0	<1.0	NA	ND - 0.2
1,1-dichloroethene	<0.25	<0.25	<1.1	<1.0	<1.0	<1.0	ND	ND
1,2-dibromoethane	<0.25	<0.25	<1.3	<1.2	<1.5	<1.5	ND	ND
1,2-dichloroethane	<0.25	<0.25	<0.6	<0.6	<1.0	<1.0	ND	ND - 0.22
1,2-dichlorobenzene	<0.25	<0.25	<0.9	<1.0	<2.0	<2.0	ND	ND - 0.23
1,2-dichloropropane	<0.25	<0.25	<1.4	<1.4	<1.0	<1.0	NA	0.1 - 0.3
1,3-dichlorobenzene	<0.25	<0.25	<0.8	<0.8	<2.0	<2.0	0.32 - 5.6	ND - 1.2
1,2,4-trimethylbenzene	0.78 - 4.4	<0.25 - 1.0	1.7 - 5.1	<1.6 - 3.1	<4.4 - 7.0	<1.0	0.6 - 4.0	2.8 - 7.4
1,3,5-trimethylbenzene	<0.25 - 1.7	<0.25 - 0.44	<1.5	<1.4	<5.0	<1.0	ND - 5.4	0.2 - 2.5
acetone	10 - 46	3.9 - 23	32 - 60	15 - 32	NA	NA	11 - 27	ND - 6.7
benzene	1.2 - 5.7	<0.25 - 2.6	2.1 - 5.1	1.2 - 3.7	<3.2 - 5	<1.6 - 4.7	3.3 - 21	2.0 - 11
bromo-dichloromethane	NA	NA	NA	NA	<10	<5.0	NA	NA
bromoform	NA	NA	NA	NA	<5.0	<1.0	ND	ND
carbon tetrachloride	<0.25 - 0.68	<0.25 - 0.68	<0.9	<1.0	<3.1	<3.1	ND - 0.8	0.4 - 0.8
chlorobenzene	<0.25	<0.25	<0.7	<0.8	<2.0	<2.0	NA	ND - 1.4
chloroform	<0.25 - 0.54	<0.25	<0.5	<0.4	<1.0 - 4.3	<2.4	ND - 3.4	0.1 - 0.9
cis-1,2-dichloroethene	<0.25	<0.25	<1.0	<1.0	<1.0	<1.0	NA	ND - 0.45
dibromo-chloromethane	NA	NA	NA	NA	<5.0	<5.0	NA	NA
ethylbenzene	0.43 - 2.8	<0.25 - 0.61	<1.6 - 3.4	<1.4 - 1.6	<3.4 - 4.8	<4.3	2.0 - 9.6	1.0 - 5.4
n-hexane	0.63 - 6.5	<0.25 - 1.1	1.6 - 6.4	<1.2 - 2.7	<1.0 - 3.6	<1.5	NA	2.9 - 10
methyl bromide (bromomethane)	<0.25	<0.25	<0.9	<1.0	<1.0	<1.0	NA	0.2 - 12
methyl chloride (chloromethane)	<0.25 - 2.0	<0.25 - 2.0	2.1 - 3.1	2.0 - 3.0	<1.0	<1.0 - 1.4	NA	1.3 - 1.5
methylene chloride	0.38 - 6.3	<0.25 - 0.87	<1.7 - 5.0	<1.8 - 3.0	<3.0 - 5.6	<3.4	NA	1.1 - 6.3
m,p-xylene	0.52 - 4.7	<0.25 - 0.69	4.1 - 12	<3.6 - 7.3	<4.4 - 9.5	<4.3	4.3 - 18	2.0 - 11
methyl-tert-butyl-ether (MTBE)	<0.25 - 6.7	<0.25 - 1.0	<1.7 - 12	<1.8	NA	NA	NA	NA
naphthalene	NA	NA	<2.5	<2.4	<10	<3.5	NA	0.2 - 5.7
o-xylene	0.39 - 3.1	<0.25 - 0.74	<2.4 - 4.4	<1.4 - 2.6	<3.8 - 5.0	<4.3	2.0 - 9.3	1.0 - 6.5
styrene	<0.25 - 0.68	<0.25	<1.8	<1.6	<1.0	<1.0	ND - 2.8	ND - 1.4
tetrachloroethene	<0.25 - 1.2	<0.25 - 0.34	<1.9 - 5.9	<1.4 - 3.0	<3.7	<3.7	1.7 - 11	0.82 - 5.9
toluene	4.2 - 25	0.68 - 3.3	10.7 - 26	5.9 - 16	6.5 - 25	1.0 - 6.1	NA	0.6 - 20
trichloroethene	<0.25	<0.25	<1.2 - 1.2	<1.5	<2.7	<1.7	ND - 4.5	0.05 - 2.5
vinyl chloride	<0.25	<0.25	<0.9	<1.0	<1.0	<1.0	NA	ND - 0.78

## **Summary of Background Levels<sup>1</sup> for Selected Compounds**

### **All Results Are Micrograms Per Cubic Meter (mcg/m<sup>3</sup>)**

<sup>1</sup>The ranges provided in the table represent the 25th percentile to 75th percentile, (middle half), of the results from the EPA and NYSDOH databases and are labeled as background. A single value is the minimum reporting limit for that compound, and indicates that more than 75% of the data are below the detection limit. These databases are comprised of air testing results from studies where there were no known sources of chemicals or chemical spills.

<sup>2</sup>Summary of Indoor and Outdoor Levels of Volatile Organic Compounds From Fuel Oil Heated Homes in NYS, 1997 to 2003. Unpublished. New York State Department of Health, Bureau of Toxic Substance Assessment.

<sup>3</sup>Building Assessment and Survey Evaluation (BASE '94-'98). Unpublished. Indoor Environments Division, United States Environmental Protection Agency, Washington, DC.

<sup>4</sup>Background Indoor/Outdoor Air Levels of Volatile Organic Compounds in Homes Sampled by the New York State Department of Health, 1989-1996. 1997. New York State Department of Health, Bureau of Toxic Substance Assessment.

<sup>5</sup>National Ambient Volatile Organic Compounds (VOCs) Data Base Update. 1988. Nero and Associates, Portland, OR, for the United States Environmental Protection Agency, Research Triangle Park, NC. EPA PB88-195631.

< Means "less than". The number following a "less than sign" (<) is the lowest level the laboratory test can reliably measure (reporting limit). If there is a "<" before any number, then the chemical was NOT detected in your sample.

NA - Not Available

ND - Not Detected. Chemical was not detected, and detection limits were not provided.



### 3.2.5 Applicable standards, criteria and guidance values

#### a. *Subsurface vapors*

The State of New York does not have any standards, criteria or guidance values for concentrations of volatile chemicals in subsurface vapors (either soil vapor or sub-slab vapor).

#### b. *Indoor and outdoor air*

The NYSDOH has developed several guidelines for chemicals in air. The development process is initiated for specific situations. For example, in New York State, particularly in New York City, dry cleaners are often located in apartment buildings. Because air in buildings mixes to some extent and the dry cleaning chemical PCE is volatile, it may migrate to residential apartments. When the NYSDOH became aware of this problem and how widespread it is, the NYSDOH developed an air guideline for PCE of 100 micrograms per cubic meter (mcg/m<sup>3</sup>). In addition to PCE, the NYSDOH has developed guidelines for methylene chloride (also referred to as dichloromethane) in air, as well as dioxin and polychlorinated biphenyls in indoor air. Each guideline went through a peer review process, in which expert scientists outside of the NYSDOH reviewed the technical documentation that describes the scientific basis for the guidance value. The peer reviewers provided technical comments on the data and methods used to derive the guidelines, each of which were addressed by the NYSDOH. Upon completion of the reviews and responses to comments, the guidelines were finalized.

The NYSDOH has also developed a guideline for TCE in air since TCE is a common environmental contaminant and a contaminant of concern at many sites. The NYSDOH guideline of 5 mcg/m<sup>3</sup> was established after an extensive evaluation of scientific information about its health effects, using methods consistent with those used by other agencies and scientific bodies. The NYSDOH has committed to a peer review process for this guideline as well.

Air guideline values derived by the NYSDOH are summarized in Table 3.1. Additional information about these guidelines is provided in the following:

- Appendix D — overview of how the NYSDOH develops air guidelines; and
- Appendix H — copies of fact sheets that discuss the air guidelines for PCE and TCE.

The purpose of a guideline is to help guide decisions about the nature of efforts to reduce exposure to the chemical. Reasonable and practical actions should be taken to reduce exposures when indoor air levels are above background, even when they are below the guideline. The urgency to complete these actions increases with indoor air levels, particularly when air levels are above the guideline, and additional actions taken if the initial actions do not sufficiently reduce levels. In all cases, the specific corrective actions to be taken depend on a case-by-case evaluation of the situation. The goal of the recommended actions is to reduce chemical levels in indoor air to as close to background as practical.

**Table 3.1** Air guideline values derived by the NYSDOH

Chemical		Air Guideline Value (mcg/m <sup>3</sup> )	Reference
methylene chloride (also referred to as dichloromethane)	MeCl	60	1
polychlorinated biphenyls	PCBs	1 <sup>*</sup>	2,3
tetrachlorodibenzo- <i>p</i> -dioxin equivalents	TCDD	0.00001 <sup>*</sup>	3,4
tetrachloroethene	PCE	100	5
trichloroethene	TCE	5	6

<sup>\*</sup>The guideline is specific to indoor air.

References:

- [1] NYSDOH. 1988. Letter from N. Kim to T. Allen, Division of Air, New York State Department of Environmental Conservation. November 28, 1988.
- [2] NYSDOH. 1985. Binghamton State Office Building (BSOB) Re-Entry Guidelines: PCBs. Document 1330P. Albany, NY: Bureau of Toxic Substance Assessment.
- [3] NYSDOH. 1988. Letter from D. Axelrod to J. Egan, New York State Office of General Services. March 8, 1988.
- [4] NYSDOH. 1984. Re-Entry Guidelines. Binghamton State Office Building. Document 0549P. Albany, NY: Bureau of Toxic Substance Assessment.
- [5] NYSDOH. 1997. Tetrachloroethene Ambient Air Criteria Document. Albany, NY: Bureau of Toxic Substance Assessment.
- [6] NYSDOH. 2003. Letter from N. Kim to D. Desnoyers, Division of Environmental Remediation, New York State Department of Environmental Conservation. October 31, 2003. [Provided in Appendix D.]

### 3.2.6 Completed or proposed remedial actions

The status and effectiveness of remedial activities are considered when making decisions pertaining to the need for additional sampling and the selection of mitigation actions. For example,

- a. if a comparison of pre-remediation and post-remediation subsurface vapor sampling results indicates negligible improvement in the quality of subsurface vapors,
  1. additional sampling may be required to document a decreasing trend in subsurface vapor concentrations;
  2. termination of mitigation system operations may not be appropriate without additional sampling; or
  3. additional remedial actions may be required to address contaminated subsurface vapors;
- b. when monitoring a building is required, it may be more cost-effective to install a mitigation system if subsurface contamination is wide-spread and is expected to take many years to remediate; and
- c. if exposures in an on-site building will be addressed concurrently by a method selected to remediate subsurface contamination (e.g., a soil vapor extraction system), installation of a mitigation system may be redundant. However, if the remedial system is not expected to be operational in the immediate future, or if it is not expected to mitigate indoor air levels in a reasonable time frame, a mitigation system may still be required. [Refer to Section 4.1 for a description of the appropriate use of concurrent techniques.]

### 3.2.7 Current and future land uses

Both current and future land uses are considered when evaluating the investigation data and determining appropriate actions for further investigation or measures to address exposures. For example,

- a. subsurface vapor sampling of an undeveloped parcel may be needed based on the data evaluation. However, sampling may be delayed as discussed in Section 2.3;
- b. air sampling of a building may be needed based on the data evaluation. However, provisions may be put in place to defer sampling until occupancy of the building is expected;
- c. if exposures are demonstrated to be occupational, rather than environmental, then the data evaluation presented in this section is not appropriate. As discussed in Section 2.11, occupational exposures are subject to investigation and evaluation procedures recommended by occupational agencies, such as OSHA, NIOSH, or ACGIH; or
- d. if actions are needed to mitigate exposures related to soil vapor intrusion should the site be developed, the appropriate mitigation method will depend upon the proposed land use — a parking lot, recreational field, single-family home, commercial building, high-rise building with underground parking, occupied or unoccupied building, etc. — since each presents a different exposure scenario.

## 3.3 **Sampling results and recommended actions**

This subsection describes the process for evaluating sampling results. It also describes actions that may be recommended based on the evaluation. The evaluation procedures and actions described may not be directly applicable to samples collected as part of an emergency response. For guidance on how to proceed in such situations, refer to Section 3.5.

### 3.3.1 Soil vapor

If soil vapor samples are collected from locations where there are no known sources of volatile chemicals, we do not expect the chemicals to reach detectable levels in the samples. However, concentrations of volatile chemicals in soil vapor are commonly detected. This is likely due to several factors, including infiltration of outdoor air into the subsurface and background interferences (similar to indoor and outdoor air [Section 3.2.4]).

New York State currently does not have any standards, criteria or guidance values for concentrations of compounds in subsurface vapors. Additionally, there are no databases available of background levels of volatile chemicals in soil vapor. In the absence of this information, soil vapor sampling results are compared to background outdoor air levels [Section 3.2.4], site-related outdoor air sampling results, the NYSDOH's guidelines for volatile chemicals in air [Table 3.1]. Soil vapor results are also reviewed "as a whole" to identify trends and spacial variations in the data [Section 3.2.1].

These comparisons are used to

- a. identify areas of relatively elevated concentrations of volatile chemicals in soil vapor;
- b. select the best approach to conduct sub-slab, indoor air and outdoor air sampling;
- c. identify possible sources of subsurface vapor contamination;
- d. monitor the progress, or verify the completion, of efforts to remediate subsurface vapor contamination (either directly or indirectly); and
- e. characterize the nature and extent of subsurface vapor contamination.

When determining appropriate actions, the following should also be considered:

- a. Soil vapor results may not indicate a traditional plume-like pattern of contamination (as is often described for groundwater). Rather, the nature and extent of contamination may follow a "hit and miss" pattern.
- b. Our experience to date indicates soil vapor results alone cannot be relied upon to rule out the need for sampling or addressing exposures at nearby buildings. For example, concentrations of volatile chemicals in sub-slab vapor samples may be substantially higher than those found in soil vapor samples at 8 feet below grade near the building (e.g., by a factor of 100 or more). Therefore, exposures are evaluated primarily based on sub-slab vapor, indoor air and outdoor air sampling results and soil vapor results are used as a tool to guide these investigations.

There are no concentrations of volatile chemicals in soil vapor that automatically trigger action or no further action. Based on the comparisons and considerations described, the following actions may be recommended:

- a. *No further soil vapor sampling*

The nature and extent of subsurface vapor contamination has been adequately characterized with respect to addressing exposures and designing measures to remediate subsurface vapor contamination (either directly or indirectly).

Sub-slab vapor samples, rather than soil vapor samples, will be used to identify potential exposures and to characterize the nature and extent of subsurface vapor contamination since soil vapor results are not following a consistent pattern (i.e., hit and miss).

- b. *Additional soil vapor sampling*

To characterize the nature and extent of subsurface vapor contamination if soil vapor results are following a consistent pattern (e.g., traditional plume-like pattern).

To identify possible sources of subsurface vapor contamination.

To verify sampling results that appear inconsistent with previous sampling and/or the current understanding of the site [Sections 3.2.1 and 3.2.2].

To resample locations where results may have been invalidated by short-circuiting (outdoor air infiltration), cross contamination, or other problems.

To monitor the progress, or verify the completion, of efforts to remediate subsurface vapor contamination (either directly or indirectly).

- c. *Sub-slab vapor, indoor air and outdoor air sampling*

Generally, if soil vapor results are fairly consistent throughout the study area, buildings closest to the site are sampled first. The investigation then proceeds outward, as necessary, on an areal basis until potential and current human exposures have been adequately addressed. If there are relatively elevated concentrations of volatile chemicals in a particular area, then the buildings in this area are also sampled.

- d. *Address exposures related to soil vapor intrusion*

Provisions on undeveloped parcels may be needed to assure the State that the parcel will not be developed without addressing exposure concerns [Sections 2.3 and 3.6].

As discussed previously, soil vapor sampling results alone typically do not drive actions to mitigate exposures in existing buildings. Rather, they guide sampling efforts in buildings. However, with the State's approval, a "blanket mitigation" approach may be taken provided the nature and extent of soil vapor contamination has been sufficiently characterized. A "blanket mitigation" approach is where an area is defined within which each building may be offered a mitigation system. The offer is made regardless of what actions may be needed based on an evaluation of air results (e.g., no further action or monitoring).

#### Notes:

- a. The recommended actions may be modified or supported upon consideration of the factors given in Section 3.2.
- b. Additional sampling may become necessary based on the migration of subsurface contamination (e.g., contaminated groundwater or vapors) or if environmental monitoring indicates a change in chemical constituents (e.g., the production of degradation products that may be more toxic than the parent compounds).

#### 3.3.2 Sub-slab vapor

The goals of collecting sub-slab vapor samples are to identify potential and current exposures associated with soil vapor intrusion and to characterize the nature and extent of subsurface vapor contamination. As discussed in Section 3.3.1, New York State currently does not have any standards, criteria or guidance values for concentrations of compounds in subsurface vapors. Additionally, there are no databases available of background levels of volatile chemicals in subsurface vapors.

The detection of volatile chemicals in sub-slab vapor samples does not necessarily indicate soil vapor intrusion is occurring or actions are needed to address exposures. The State makes these determinations, taking the following into account:

- a. the sampling results — sub-slab vapor, indoor air, outdoor air, soil vapor;
- b. background concentrations of volatile chemicals in indoor air;
- c. the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];
- d. human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air;
- e. attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations), and
- f. the factors described in Section 3.2.

Based on this evaluation, the following actions may be recommended:

#### a. *No further action*

When the volatile chemical is not detected in the indoor air and sub-slab sample results are not expected to substantially affect indoor air quality.

#### b. *Additional sampling*

Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, may be needed to determine whether concentrations in indoor air or sub-slab vapor have changed. This action is typically recommended when sub-slab vapor concentrations are relatively elevated (also based on the nature and extent of contamination in all environmental media). It is also recommended to determine what affect, if any, active soil and groundwater remediation techniques (e.g., chemical oxidation, air sparging, etc.) may be having on subsurface vapor and indoor air quality. The type and frequency of monitoring is determined on a site-

specific and building-specific basis, taking into account applicable environmental data and building operating conditions.

Resampling may be necessary if samples were collected outside of the heating season. As discussed in Section 2.6.2, results obtained outside of the heating season may not be used to rule out exposures related to soil vapor intrusion.

c. *Mitigate*

Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. Mitigation methods are described in Section 4.

Notes:

- a. The NYSDOH, in conjunction with other agencies, has developed an approach for addressing exposures related to soil vapor intrusion based on sub-slab soil vapor and indoor air concentrations. The approach is outlined in a matrix, referred to as a decision matrix. The matrix essentially encapsulates the data evaluation process and recommended actions discussed in this subsection. Decision matrices are described in Section 3.4.
- b. The recommended actions may be modified or supported upon consideration of the factors given in Section 3.2.
- c. Additional sampling may become necessary based on the migration of subsurface contamination (e.g., contaminated groundwater or vapors) or if environmental monitoring indicates a change in chemical constituents (e.g., the production of degradation products that may be more toxic than the parent compounds).
- d. Monitoring and mitigation measures to address exposures related to soil vapor intrusion are considered interim measures implemented until contaminated environmental media (e.g., soil, groundwater and/or soil vapor) are remediated.
- e. More conservative actions than those provided above may be implemented at any time. For example, the decision to implement more conservative actions may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.
- f. Additional sampling associated with post-mitigation testing, operation, maintenance and monitoring activities, and termination of mitigation system operations is described in Section 4.

### 3.3.3 Indoor air

Indoor air samples are used to assess current exposures to volatile chemicals in air. The detection of volatile chemicals in indoor air does not necessarily indicate soil vapor intrusion is occurring or actions are needed to address exposures. These determinations are based on an evaluation of all the data.

When evaluating indoor air data, the results are compared to background levels of volatile chemicals in indoor air [Section 3.2.4] and the NYSDOH's guidelines for volatile chemicals in air [Table 3.1]. If the results are comparable to background levels, then no further action to address *current* human exposures is necessary. However, additional sampling may be necessary if

- a. samples were collected outside of the heating season. As discussed in Section 2.6.3, results obtained outside of the heating season may not be used to rule out exposures related to soil vapor intrusion;
- b. the potential for exposures related to soil vapor intrusion needs to be monitored based on the sub-slab vapor results [Section 3.3.2]; and/or
- c. subsurface conditions change over time (e.g., due to the migration of contaminated groundwater or vapors).

If the concentrations of volatile chemicals are substantially above background levels or above the NYSDOH's guidelines for volatile chemicals in air, then the likely cause of the exposure must be determined. Understanding the source is crucial for selecting the best method to address exposures. For example, although a volatile chemical may be detected in the sub-slab vapor sample, the results may indicate that indoor air effects are more likely to be coming from products stored in the building or from outdoor air rather than from contaminated soil vapors. Therefore, a sub-slab depressurization system to minimize exposures associated with soil vapor intrusion may not be appropriate.

As discussed in Sections 1.4 and 3.2.3, volatile chemicals may be present in the indoor air due to any one, or a combination, of the following:

- a. the indoor environment itself and/or building characteristics;
- b. off-gassing of volatile chemicals from contaminated water that may enter the building at the tap or shower head, or during flooding events, or contaminated water that rests in a sump or a subsurface drain;
- c. outdoor sources; and/or
- d. migration from the subsurface (i.e., soil vapor intrusion).

To determine the likely cause, the following assessment is completed:

- a. qualitative and quantitative comparisons are made between the types and concentrations of the contaminants found in the indoor air sample(s) and those found in the outdoor air and sub-slab vapor sample;
- b. qualitative and quantitative comparisons are made between indoor air results obtained in different locations of the building (e.g., different floors or rooms);
- c. indoor air results are compared to the product inventory to evaluate the extent to which indoor sources or building characteristics are affecting indoor air quality; and
- d. the indoor air quality questionnaire and building inventory form is reviewed to identify potential preferential pathways for soil vapor intrusion into the building, potential outdoor sources of volatile chemicals to the outdoor air (e.g., gasoline station or dry cleaner), and routes of air distribution within the building (e.g., HVAC system operations, airflow observations, etc.).

If a likely source or multiple sources can be identified from the available information, one or more of the following actions may be recommended given the source:

- a. *Indoor source or building characteristics*

Products containing volatile chemicals should be tightly capped. Alternatively, the products can be stored in places where people do not spend much time, such as a garage or outdoor shed. If the products are no longer needed, consideration should

be given to disposing of them properly (e.g., hazardous waste cleanup days). The list of products and corresponding readings from field instrumentation provided in the product inventory [Appendix B] can help identify products that may be contributing to the levels that were detected in the indoor air.

If exposures are assumed to be associated with off-gassing of new building materials, paint, etc., resampling may be necessary to confirm this assumption.

b. *Off-gassing from contaminated groundwater within the building*

Measures should be taken to prevent contaminated groundwater from entering the house (e.g., filter on private well supply, sealed sump, etc.).

c. *Outdoor source*

No further action, unless an evaluation of the outdoor air results [Section 3.3.4] indicates a need.

d. *Soil vapor intrusion*

Depending upon the relationship between indoor air concentrations and sub-slab vapor concentrations, monitoring or mitigation actions are needed. This determination is made by the State.

1. Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, may be needed to determine whether concentrations in indoor air or sub-slab vapor have changed. This action is typically recommended when sub-slab vapor concentrations are relatively elevated (also based on the nature and extent of contamination in all environmental media). It is also recommended to determine what affect, if any, active soil and groundwater remediation techniques (e.g., chemical oxidation, air sparging, etc.) may be having on subsurface vapor and indoor air quality. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions.
2. Methods to mitigate exposures related to soil vapor intrusion are described in Section 4.

Likely sources may not be evident given the information available. Therefore, the above recommendations cannot be made. This situation most often arises for the following reasons:

- a. Interfering indoor sources are identified. However, the possibility of vapor intrusion cannot be ruled out due to the concentrations of the same volatile chemicals detected in the sub-slab vapor sample. Differentiating the contribution of each source is not possible.
- b. Indoor air samples were collected without concurrent outdoor air and sub-slab vapor samples. Depending upon other information that may be available (e.g., building inventory and well-characterized subsurface vapor contamination), identifying likely sources and recommending appropriate actions may not be possible.
- c. All appropriate air samples are collected. However, the indoor air quality questionnaire and building inventory forms are filled out incompletely or incorrectly. The contribution of indoor sources cannot be evaluated.



When the source(s) of volatile chemicals to indoor air cannot be identified with confidence, resampling is typically recommended with corrections made as appropriate. For example, using the three scenarios presented above:

- a. resampling occurs after interferences are removed;
- b. concurrent indoor air, outdoor air and sub-slab vapor samples are collected; and
- c. an indoor air quality questionnaire and building inventory form is filled out completely and correctly when samples are collected.

Notes: See notes presented in Section 3.3.2.

#### 3.3.4 Outdoor air

Outdoor air sampling results are primarily used to evaluate the extent to which outdoor air may be affecting indoor air quality [Section 3.3.3]. They may also be used to when evaluating soil vapor results [Section 3.3.1].

The detection of volatile chemicals in outdoor air does not necessarily indicate that actions are needed to address exposures. As discussed in Section 3.2.3, volatile chemicals may be present in outdoor air due to emissions from automobiles, lawn mowers, oil storage tanks, gasoline stations, and dry cleaners or other commercial and industrial facilities.

When evaluating outdoor air data, the results are compared to background levels of volatile chemicals in outdoor air [Section 3.2.4] and the NYSDOH's guidelines for volatile chemicals in air [Table 3.1]. If the results are comparable to background levels, then no further action to address human exposures is necessary.

If the results are substantially above outdoor air background concentrations or above the NYSDOH's guidelines, the following actions may be necessary:

##### a. *Additional sampling*

Resample to verify the results if they appear inconsistent with previous outdoor air sampling results or the current understanding of the site.

Collect additional samples to characterize the nature and extent of outdoor air contamination.

##### b. *Identify potential sources and address as necessary*

Take reasonable and practical steps to identify potential sources of volatile chemicals to the outdoor air (e.g., nearby commercial or industrial facility) and to address accordingly. For example, concentrations of benzene, ethylbenzene, toluene and xylenes may be above background levels due to the presence of gasoline stations on the same block. The results would be reflective of site-specific background conditions and no further action would be necessary.

Note: These recommended actions may be modified or supported upon consideration of the factors given in Section 3.2.

### 3.4 **Decision matrices**

#### 3.4.1 Overview

Decision matrices are risk management tools, developed by the NYSDOH in conjunction with other agencies, to provide guidance on a case-by-case basis about actions that should be taken to address current and potential exposures related to soil vapor intrusion. The matrices encapsulate the data evaluation processes and actions recommended to address

exposures discussed in Sections 3.3.2 and 3.3.3. The general format of a decision matrix is shown in Table 3.2.

**Table 3.2** General format of a decision matrix

Sub-slab Vapor Concentration of Volatile Chemical (mcg/m <sup>3</sup> )	Indoor Air Concentration of Volatile Chemical (mcg/m <sup>3</sup> )		
	Concentration Range 1	Concentration Range 2	Concentration Range 3
Concentration Range 1	ACTION	ACTION	ACTION
Concentration Range 2	ACTION	ACTION	ACTION
Concentration Range 3	ACTION	ACTION	ACTION

Indoor air and sub-slab vapor concentration ranges in a matrix are selected based on a number of considerations in addition to health risks. For example, factors that are considered when selecting the ranges include, but are not limited to, the following:

- human health risks (i.e., cancer and non-cancer health effects) associated with exposure to the volatile chemical in air;
- the NYSDOH's guidelines for volatile chemicals in air [Table 3.1];
- background concentrations of volatile chemicals in indoor air [Section 3.2.4];
- analytical capabilities currently available; and
- attenuation factors (i.e., the ratio of indoor air to sub-slab vapor concentrations).

### 3.4.2 Matrices

The NYSDOH has developed two matrices, which are included at the end of this subsection, to use as tools in making decisions when soil vapor may be entering buildings. The first matrix was originally developed for TCE and the second matrix was originally developed for PCE. Because the matrices are risk management tools and consider a number of factors, the NYSDOH intends to assign chemicals to one of these two matrices, if possible. Additional matrices will be developed when a chemical's toxicologic properties, background concentrations, or analytical capabilities suggest that major revisions are needed. To date, three chemicals have been assigned to the two matrices. TCE is assigned to Soil Vapor/Indoor Air Matrix 1 while PCE and 1,1,1-trichloroethane (1,1,1-TCA) are assigned to Soil Vapor/Indoor Air Matrix 2.

The considerations in assigning a chemical to a matrix include the following:

- human health risks, including such factors as a chemical's ability to cause cancer, reproductive, developmental, liver, kidney, nervous system, immune system or other effects, in animals and humans and the doses that may cause those effects;
- the data gaps in its toxicologic database;
- background concentrations of volatile chemicals in indoor air [Section 3.2.4]; and
- analytical capabilities currently available.

To use the matrices accurately as a tool in the decision-making process, the following must be noted:

- a. The matrices are generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. For example, the decision to implement more conservative actions may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.
- b. Indoor air concentrations detected in samples collected from the building's basement or, if the building has a slab-on-grade foundation, from the building's lowest occupied living space should be used.
- c. Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.
- d. When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix and to support assessment and follow-up by the agencies.

### 3.4.3 Description of recommended actions

Actions recommended in the matrix are based on the relationship between sub-slab vapor concentrations and corresponding indoor air concentrations. They are intended to address both potential and current human exposures and include the following:

- a. *No further action*  
When the volatile chemical is not detected in the indoor air sample and the concentration detected in the corresponding sub-slab vapor sample is not expected to substantially affect indoor air quality.
- b. *Take reasonable and practical actions to identify source(s) and reduce exposures*  
The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile chemical-containing products in places where people do not spend much time, such as a garage or shed).
- c. *Monitor*  
Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure HVAC systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed.

The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions.

d. *Mitigate*

Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. Methods to mitigate exposures related to soil vapor intrusion are described in Section 4.

# Soil Vapor/Indoor Air Matrix 1

WORKING DRAFT 02.23.05

SUBJECT TO CHANGE

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m <sup>3</sup> )	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m <sup>3</sup> )			
	< 0.25	0.25 to < 2.5	2.5 to < 5.0	5.0 and above
< 5	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures  — and —  Monitor	4. MITIGATE  — or —  Take reasonable and practical actions to identify source(s) and reduce exposures  — and —  Monitor
5 to < 50	5. No further action	6. Monitor	7. Monitor	8. MITIGATE
50 to < 250	9. Monitor	10. Monitor	11. MITIGATE	12. MITIGATE
250 and above	13. MITIGATE	14. MITIGATE	15. MITIGATE	16. MITIGATE

**No further action:** Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

**Take steps to identify source(s) and reduce exposures:** The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed).

**Monitor as appropriate:** Monitoring is needed to confirm concentrations in the indoor air have not increased due to changes in pressure gradients (e.g., deterioration of building foundation) or to evaluate temporal trends for relevant environmental data. Monitoring may also be needed to verify that existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are minimizing potential effects associated with soil vapor intrusion. The type and frequency of monitoring is determined on a site-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

**Mitigate:** Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is considered a temporary measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

## ADDITIONAL NOTES FOR MATRIX 1

---

This matrix provides guidance on actions that should be taken to address current and potential exposures related to soil vapor intrusion. To use the matrix accurately as a tool in the decision-making process, the following must be noted:

- [1] The matrix is generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. For example, the decision to implement more conservative actions may be based on a comparison of the costs associated with resampling or monitoring to the costs associated with installation and monitoring of a mitigation system.
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.
- [3] Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples must be analyzed by methods that can achieve a minimum reporting limit of 0.25 microgram per cubic meter for indoor and outdoor air samples, and typically 1 microgram per cubic meter for subsurface vapor samples.
- [4] Sub-slab vapor and indoor air samples are typically collected during the heating season since soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. If samples are collected during other times of the year, it may be necessary to resample during the heating season to evaluate exposures accurately.
- [5] When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.

# Soil Vapor/Indoor Air Matrix 2

WORKING DRAFT 02.23.05

SUBJECT TO CHANGE

SUB-SLAB VAPOR CONCENTRATION of COMPOUND (mcg/m <sup>3</sup> )	INDOOR AIR CONCENTRATION of COMPOUND (mcg/m <sup>3</sup> )			
	< 3	3 to < 30	30 to < 100	100 and above
< 100	1. No further action	2. Take reasonable and practical actions to identify source(s) and reduce exposures	3. Take reasonable and practical actions to identify source(s) and reduce exposures  — and —  Monitor	4. MITIGATE  — or —  Take reasonable and practical actions to identify source(s) and reduce exposures  — and —  Monitor
100 to < 1,000	5. Monitor	6. Monitor	7. MITIGATE	8. MITIGATE
1,000 and above	9. MITIGATE	10. MITIGATE	11. MITIGATE	12. MITIGATE

**No further action:** Given that the compound was not detected in the indoor air sample and that the concentration detected in the sub-slab vapor sample is not expected to significantly affect indoor air quality, no additional actions are needed to address human exposures.

**Take steps to identify source(s) and reduce exposures:** The concentration detected in the indoor air sample is likely due to indoor and/or outdoor sources rather than soil vapor intrusion given the concentration detected in the sub-slab vapor sample. Therefore, steps should be taken to identify potential source(s) and to reduce exposures accordingly (e.g., by keeping containers tightly capped or by storing volatile organic compound-containing products in places where people do not spend much time, such as a garage or outdoor shed).

**Monitor:** Monitoring, including sub-slab vapor, basement air, lowest occupied living space air, and outdoor air sampling, is needed to determine whether concentrations in the indoor air or sub-slab vapor have changed. Monitoring may also be needed to determine whether existing building conditions (e.g., positive pressure heating, ventilation and air-conditioning systems) are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined on a site-specific and building-specific basis, taking into account applicable environmental data and building operating conditions. Monitoring is an interim measure required to evaluate exposures related to soil vapor intrusion until contaminated environmental media are remediated.

**Mitigate:** Mitigation is needed to minimize current or potential exposures associated with soil vapor intrusion. The most common mitigation methods are sealing preferential pathways in conjunction with installing a sub-slab depressurization system, and changing the pressurization of the building in conjunction with monitoring. The type, or combination of types, of mitigation is determined on a building-specific basis, taking into account building construction and operating conditions. Mitigation is an interim measure implemented to address exposures related to soil vapor intrusion until contaminated environmental media are remediated.

## ADDITIONAL NOTES FOR MATRIX 2

---

This matrix provides guidance on actions that should be taken to address current and potential exposures related to soil vapor intrusion. To use the matrix accurately as a tool in the decision-making process, the following must be noted:

- [1] The matrix is generic. As such, it may be necessary to modify recommended actions to accommodate building-specific conditions (e.g., dirt floor in basement, crawl spaces, etc.) and/or site-specific conditions (e.g., proximity of building to identified subsurface contamination) for the protection of public health. Additionally, actions more conservative than those specified within the matrix may be implemented at any time. More conservative actions are often cost-based (e.g., the cost of additional sampling versus the cost of mitigation) rather than health-based.
- [2] Actions provided in the matrix are specific to addressing human exposures. Implementation of these actions does not preclude the need to investigate possible sources of vapor contamination, nor does it preclude the need to remediate contaminated soil vapors or the source of soil vapor contamination.
- [3] Extreme care should be taken during all aspects of sample collection to ensure that high quality data are obtained. Since the data are being used in the decision-making process, the laboratory analyzing the environmental samples must have current Environmental Laboratory Approval Program (ELAP) certification for the appropriate analyte and environmental matrix combinations. Furthermore, samples must be analyzed by methods that can achieve a minimum reporting limit of 3 micrograms per cubic meter.
- [4] Sub-slab vapor and indoor air samples (basement and lowest occupied living space) are typically collected during the heating season since soil vapor intrusion is more likely to occur when a building's heating system is in operation and air is being drawn into the building. If samples are collected during other times of the year, it may be necessary to resample during the heating season to evaluate exposures accurately.
- [5] When current exposures are attributed to sources other than vapor intrusion, the agencies must be provided documentation (e.g., applicable environmental data, completed indoor air sampling questionnaire, digital photographs, etc.) to support a proposed action other than that provided in the matrix box and to support agency assessment and follow-up.



### 3.5 Emergency response

The NYSDOH's staff are responsible for recommending that residents relocate in cases where there may be health risks resulting from exposure to petroleum spills. These roles and responsibilities are outlined in Environmental Health Manual Technical Reference and Procedural Items BTSA-01. Air sampling is necessary in some cases for demonstrating that spill cleanup and engineering controls have been effective in reducing indoor air impacts and associated health risks to residents. At a minimum, air samples are collected from the basement, first floor and from outdoors. The need for sub-slab or soil gas samples is evaluated on a case-by-case basis. Air testing data are sometimes used as the basis for ending emergency relocation financial support. For additional information, please contact the NYSDOH's Bureau of Toxic Substance Assessment by calling 1-800-458-1158.

Emergency actions not related to petroleum spills are handled on a case-by-case basis.

### 3.6 Undeveloped parcels

If investigation of an undeveloped parcel is being delayed until the site is being developed, measures need to be in place that assure the State that no development will occur without addressing the exposures. Institutional controls may be used for this purpose. An institutional control is any non-physical means of enforcing a restriction on the use of real property that

- a. limits human or environmental exposure,
- b. provides notice to potential owners, operators or members of the public, or
- c. prevents actions that would interfere with the effectiveness of remedial actions or with the effectiveness and/or integrity of operation, maintenance or monitoring activities at a site.

An institutional control that is often used is an environmental easement. An environmental easement is an enforced mechanism used for property where the remedial actions leave residual contamination that makes the property suitable for some, but not all uses, or includes engineering controls that must be maintained for the easement to be effective. The purpose of the easement is to ensure that such use restrictions or engineering controls remain in place. An environmental easement

- a. can only be created by the property owner (the *grantor*) through a written instrument recorded in the appropriate county recording office. It can only be granted to the State (the *grantee*) and can only be extinguished or amended by a written instrument executed by the Commissioner of the Department of Environmental Conservation and duly recorded;
- b. is binding upon all subsequent owners and occupants of the property. The deed or deeds for the property (as well as any other written instruments conveying any interest in the property) must contain a prominent notice that it is subject to an environmental easement; and
- c. may be enforced in perpetuity against the *grantor*, subsequent owners of the property, lessees, and any person using the property by its grantor, by the State, or by the municipality in which the property is located.

If these actions cannot be implemented, alternative measures must be in place that assure the State that the parcel will not be developed without addressing the exposure concerns. For example, arrangements should be made for the town, village or city to notify the appropriate party when new construction is proposed for the parcel (e.g., permit applications and grants) or ownership of the parcel changes.

## Section 4: Soil Vapor Intrusion Mitigation

As discussed in Section 1.1, soil vapor can enter a building through cracks or perforations in slabs or basement floors and walls, and through openings around sump pumps or where pipes and electrical wires go through the foundation primarily because of a difference between interior and exterior pressures. This intrusion is similar to how radon gas enters buildings from the subsurface. Fortunately, given this similarity, well-established techniques for mitigating exposures to radon may also be used to mitigate exposures related to soil vapor intrusion.

Once it is determined that steps need to be taken to address exposures associated with soil vapor intrusion, they must be implemented without delay. This section provides an overview of the basic requirements with respect to

- a. methods of mitigation,
- b. installation and design of mitigation systems,
- c. post-mitigation testing,
- d. operation, maintenance and monitoring of mitigation systems,
- e. termination of mitigation system operations, and
- f. annual certification.

### 4.1 Methods of mitigation

The most effective mitigation methods involve sealing infiltration points and actively manipulating the pressure differential between the building's interior and exterior. As discussed in the following subsections, the appropriate method to use will largely depend upon the building's foundation design. Furthermore, buildings having more than one foundation design feature (e.g., a basement under one portion of the house and a crawlspace beneath the remainder) will likely require a combination of mitigation methods.

#### 4.1.1 Buildings with a basement slab or slab-on-grade foundation

In conjunction with *sealing* potential subsurface vapor entry points, an active *sub-slab depressurization system* (SSD system) must be used in buildings with a basement slab or slab-on-grade foundation. A SSD system uses a fan-powered vent and piping to draw vapors from the soil beneath the building's slab (i.e., essentially creating a vacuum beneath the slab) and discharge them to the atmosphere. This results in lower sub-slab air pressure relative to indoor air pressure, which prevents the infiltration of sub-slab vapors into the building.

The most common approach to achieving depressurization beneath the slab is to insert the piping through the floor slab into the crushed rock or soil underneath. However, some buildings may have special features that are conducive to different depressurization approaches, such as the following:

- a. *Drain tile suction* — Some houses have drain tiles or perforated pipe to direct water away from the foundation of the house. Suction on these tiles or pipes is often effective;
- b. *Sump hole suction* — If the building has a sump pump to remove unwanted water, the sump can be capped so that it can continue to drain water and serve as the location for piping. If the sump is not used as the suction or extraction point, the associated wiring and piping should be sealed and an air-tight cover should be installed to enhance the performance of the SSD system; and

- c. *Block wall suction* — If the building has hollow block foundation walls, the void network within the wall may be depressurized by drawing air from inside the wall and venting it to the outside. This method is often used in combination with sub-slab depressurization.

Although sealing is not a reliable mitigation technique on its own, it can significantly improve the effectiveness of a SSD system since it limits the flow of subsurface vapors into the building. All joints, cracks and other penetrations of slabs, floor assemblies and foundation walls below or in contact with the ground surface should be sealed with materials that prevent air leakage.

If the State concurs that a SSD system is not a practicable alternative or that exposures will be mitigated concurrently by a method selected to remediate subsurface contamination, alternative mitigation methods may be considered, such as the following:

- a. *HVAC modification* — a technique where the building's HVAC system is modified to avoid depressurization of the building relative to underlying and surrounding soil (i.e., to maintain a positive pressure within the building); and
- b. *Soil vapor extraction (SVE) system* — a technique used to remediate contaminated subsurface soil vapor. SVE systems use high flow rates to collect and remove contamination, while SSD systems use a minimal flow rate to effect the minimum pressure gradient (0.002 inch water) needed to reverse air flow across a building's foundation. Depending upon the SVE system's design, the system may also serve to mitigate exposures. For example, the SVE system's radius of influence includes the subsurface beneath affected buildings or horizontal legs of the system will be installed beneath affected buildings. However, complications can arise if the SVE system is no longer effective at remediating contaminated vapors, but there is still a need to mitigate exposures due to residual vapor contamination.

#### 4.1.2 Buildings with a crawlspace foundation

A *soil vapor retarder with sub-membrane depressurization (SMD) system* must be used in buildings with a crawlspace foundation. A soil vapor retarder is a synthetic membrane or other comparable material that is placed on the ground in the crawlspace to retard the flow of soil vapors into the building. A SMD system is similar to a SSD system. It uses a fan-powered vent and piping to draw vapors from beneath the soil vapor retarder and discharge them to the atmosphere. This results in lower air pressure beneath the membrane relative to air pressure in the crawlspace, which prevents the infiltration of subsurface vapors into the building.

If the State concurs that a soil vapor retarder with a SMD system is not a practicable alternative or that exposures will be mitigated concurrently by a method selected to remediate subsurface contamination, alternative mitigation methods may be considered, such as the following:

- a. *HVAC modification* — a technique where the building's HVAC system is modified to avoid depressurization of the building relative to the crawlspace;
- b. *Crawlspace ventilation with sealing* — a technique that uses a fan to draw air out of the crawlspace; and
- c. *SVE system* [Section 4.1.1].

#### 4.1.3 Buildings with dirt floor basements

Either a SSD system with a newly poured slab or a SMD system with a soil vapor retarder may be used. However, the former method is preferred.

#### 4.1.4 Buildings with multiple foundation types

Mitigation in a building with a combination of foundations should be achieved by applying the specific methods described previously [Sections 4.1.1 through 4.1.3] to the corresponding foundation segments of the building. Special consideration must be given to the points at which different foundation types join, since additional soil vapor entry routes exist in such locations. Often, the various systems can be installed and connected to a common depressurization system and fan.

#### 4.1.5 Undeveloped parcels

If sampling results indicate a need to mitigate exposures in buildings that may be constructed [Section 3.3], a SSD system with sealing, or a SMD system with a soil vapor retarder, or a combination of these methods must be used based upon the design of the proposed buildings.

#### 4.1.6 Additional references

The following documents provide additional information on selecting an appropriate mitigation method:

a. *A Consumer's Guide to Radon Reduction*

USEPA [EPA 402-K-03-002, revised February 2003]

This document provides assistance in selecting a qualified radon mitigation contractor to reduce the radon levels in a home, determining an appropriate radon reduction method, and maintaining a radon reduction system. It is available at the USEPA's website: <http://www.epa.gov/iaq/radon/pubs/index.html>; and

b. *Reducing Radon in Schools: A Team Approach*

USEPA [EPA 402-R-94-008, April 1994]

This document will provide assistance in determining the best way to reduce elevated radon levels found in a school. It provides guidance on the process of confirming a radon problem, selecting the best mitigation strategy, and directing the efforts of a multidisciplinary team assembled to address elevated radon levels in a way that will contribute to the improvement of the overall indoor air quality of the school. Copies can be ordered from the USEPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318.

## 4.2 **Design and installation of mitigation systems**

Once a mitigation method is selected, it must be designed and installed. The general requirements for the design and installation of mitigation systems, the basic requirements for specific mitigation techniques, and references for technical guidance are provided in the following subsections.

### 4.2.1 General requirements

Systems must be designed and installed by a professional engineer or environmental professional acceptable to the State. In most areas of the state, there are contractors who have met certain requirements and are trained to identify and fix radon problems in buildings. To obtain the names of local contractors, contact the NYSDOH's Radon Program at 1-800-458-1158, extension 27556, or visit the National Radon Safety Board's website ([www.nrsb.org](http://www.nrsb.org)) or National Environmental Health Association's website ([www.neha.org](http://www.neha.org)).

Typically, the party responsible for remediating the site is responsible for arranging design and installation activities. If no responsible party is available, the State will arrange for the design and installation of the system. All design and installation activities must be

documented and reported to the agencies. Furthermore, once a mitigation system is installed, an information package must be given to the building's owner and tenants, if applicable, to facilitate their understanding of the system's operation, maintenance and monitoring [Section 5.6].

With the exception of SVE systems, the mitigation methods introduced in Section 4.1 are not intended to remediate the source of subsurface vapors (e.g., contaminated groundwater, soil, etc.). Rather, they are designed to minimize the infiltration of subsurface vapors into a building. For consistency in implementing the techniques in residential buildings, mitigation systems should be designed and installed in accordance with the following:

a. *Radon Mitigation Standards*

USEPA [EPA 402-R-93-078, revised April 1994]

This document applies to existing buildings. The purpose of this document is to provide radon mitigation contractors with uniform standards that will ensure quality and effectiveness in the design, installation, and evaluation of radon mitigation systems in detached and attached residential buildings three stories or less in height. A copy of the standards is provided in Appendix E; and

b. *Model Standards and Techniques for Control of Radon in New Residential Buildings*

USEPA [EPA 402-R-94-009, March 1994]

This document applies to new construction and contains information on how to incorporate radon reduction techniques and materials in residential construction. A copy of this document is provided in Appendix F.

#### 4.2.2 System-specific requirements

Basic design and installation requirements for mitigation systems follow. These are based upon requirements and recommendations given by the USEPA for mitigating exposures related to radon intrusion, including those specified in the USEPA's *Radon Mitigation Standards* [Appendix E] and *Model Standards and Techniques for Control of Radon in New Residential Buildings* [Appendix F].

- a. *Sealing* — To improve the effectiveness of depressurization and ventilation systems and to limit the flow of subsurface vapors into the building, materials that prevent air leakage should be used, such as elastomeric joint sealant (as defined in ASTM C920-87), compatible caulks, non-shrink mortar, grouts, expanding foam, "Dranjer" drain seals, or airtight gaskets.
- b. *Soil vapor retarder (membrane)* —
  1. To retard the infiltration of subsurface vapors into the building and enhance the performance of a SMD system, a minimum 6 mil (or 3 mil cross-laminated) polyethylene or equivalent flexible sheeting material should be used.
  2. The sheet should cover the entire floor area and be sealed at seams (with at least a 12 inch overlap) and penetrations, around the perimeter of interior piers and to the foundation walls.
  3. Enough of the sheeting should be used so it will not be pulled away from the walls when the depressurization system is turned on and the sheet is drawn down.

c. *Depressurization systems —*

1. The systems must be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).
2. The systems must be designed to minimize soil vapor intrusion effectively while considering the need to minimize excess energy usage, to avoid compromising moisture and temperature controls and other comfort features, and to minimize noise.
3. To evaluate the potential effectiveness of a SSD before it is installed, a diagnostic test (commonly referred to as a "communication" test) must be performed to measure the ability of a suction field and air flow to extend through the material beneath the slab. This test is commonly conducted by applying suction on a centrally located hole drilled through the concrete slab and simultaneously observing the movement of smoke downward into small holes drilled in the slab at locations separated from the central suction hole. A similar quantitative evaluation may also be performed by using a digital micromanometer or comparable instrument.
4. Passive systems (i.e., a SSD system without a vent fan) are not as effective as active systems and their performance varies depending upon ambient temperatures and wind conditions. Therefore, active systems must be used to ensure exposures are being addressed.
5. The vent fan and discharge piping must not be located in or below a livable or occupied area of the building to avoid entry of subsurface vapors into the building in the event of a fan leak.
6. To avoid entry of subsurface vapors into the building, the vent pipe's exhaust must be
  - i. above the eave of the roof (preferably, above the highest eave of the building at least 12 inches above the surface of the roof),
  - ii. at least 10 feet above ground level,
  - iii. at least 10 feet away from any opening that is less than 2 feet below the exhaust point, and
  - iv. 10 feet from any adjoining or adjacent buildings, or HVAC intakes or supply registers.
7. Caps, if used, must be placed on the exhaust point so as not to increase the potential for subsurface vapors to enter the building.
8. To avoid accidental changes to the system that could disrupt its function, the depressurization system must be labeled clearly. An example of such labeling is shown in Figure 5.1.
9. A warning device must be installed to alert building occupants if the active system stops working properly. Examples of system failure warning devices include the following: a liquid gauge (e.g., a manometer), a sound alarm, a light indicator, and a dial (needle display) gauge. The warning device must be placed where it can be seen or heard easily. The party installing the system should verify the warning device is working properly. Building occupants must be made aware of the warning device (what it is, where it is located, how it

works, how to read/understand it, and what to do if it indicates the system is not working properly).

- d. *HVAC systems* — HVAC systems should be carefully designed, installed and operated to avoid depressurization of basements and other areas in contact with the soil.
- e. *Crawlspace ventilation* —
  1. Ventilation systems must be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).
  2. Openings and cracks in floors above the crawlspace that would permit conditioned air to pass out of the occupied spaces of the building, must be identified, closed and sealed.
- f. *SVE systems designed to also mitigate exposures* —
  1. The systems must be designed to avoid the creation of other health, safety, or environmental hazards to building occupants (e.g., backdrafting of natural draft combustion appliances).
  2. To avoid reentry of soil vapor into the building(s), the exhaust point must be located away from the openings of buildings and HVAC air intakes. Depending upon the concentrations of volatile chemicals in subsurface vapors and the expected mass removal rate, treatment (e.g., via carbon filters) of the SVE system effluent may be necessary to minimize outdoor air effects.
  3. The SVE system's radius of influence must adequately address buildings requiring mitigation, as well as subsurface sources requiring remediation. If it does not, additional actions may be required. For example, if the radius of influence does not completely extend beneath a building, a complementary air monitoring program may be required to confirm that exposures are being addressed adequately while the SVE system is operating.

#### 4.2.3 Technical guidance

To address exposures effectively in larger buildings, some of the same techniques used in residential buildings can be scaled up in size, number, or performance (e.g., adjustments in the size and air movement capacity of the vent pipe fan, or installation of multiple suction points through the slab instead of a single point). The design of the techniques may also be modified (e.g., installation of horizontal pipes beneath the building instead of a single suction point).

Detailed technical guidance on designing and installing mitigation systems in residential, as well as non-residential, buildings is provided in the following references:

- a. References provided in the USEPA's *Radon Mitigation Standards* (Appendix E) and *Model Standards and Techniques for Control of Radon in New Residential Buildings* (Appendix F);
- b. *Radon Reduction Techniques for Existing Detached Houses: Technical Guidance (Third Edition) for Active Soil Depressurization Systems*  
USEPA [EPA 625/R-93-011, October 1993]

This technical guidance document has been prepared to serve as a comprehensive aid in the detailed selection, design, installation, and operation of indoor radon reduction measures for existing houses based on active soil depressurization

techniques. It is intended for use by radon mitigation contractors, building contractors, concerned homeowners, state and local officials and other interested persons. Copies can be ordered from the USEPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318;

- c. *Protecting Your Home From Radon: A Step-by-Step Manual for Radon Reduction* Kladder *et al.*, 1993

This manual is designed to provide sufficient information to a homeowner to make many of the basic repairs that can significantly reduce radon levels in the home;

- d. *Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes* USEPA [EPA 402-K-01-002, April 2001]

This fully illustrated guide contains all the information needed in one place to educate home builders about radon-resistant new construction (RRNC), including the following: basic questions and detailed answers about radon and RRNC, specific planning steps before installing a system, detailed installation instructions with helpful illustrations, tips and tricks when installing a system, marketing know-how when dealing with homebuyers, and architectural drawings. This document is available at the USEPA website: <http://www.epa.gov/iaq/radon/pubs/index.html>; and

- e. *Radon Prevention in the Design and Construction of Schools and Other Large Buildings* USEPA [EPA 625-R-92-016, June 1994]

It is typically easier and much less expensive to design and construct a new building with radon-resistant and/or easy-to-mitigate features, than to add these features after the building is completed and occupied. Specific guidelines on how to incorporate radon prevention features in the design and construction of schools and other large buildings are detailed in this manual. Copies can be ordered from the USEPA's Indoor Air Quality Information Clearinghouse at 1-800-438-4318. This document is also available on the USEPA Office of Research and Development's website: <http://www.epa.gov/ordntrnt/ORD/NRMRL/Pubs/1993/air/EPA625r-92016.htm>.

### 4.3 Post-mitigation or confirmation testing

Once a mitigation system is installed, its effectiveness and proper installation must be confirmed. The party that installed the system is responsible for conducting post-mitigation testing and for developing a post-mitigation testing plan. Minimum requirements for post-mitigation testing associated with specific mitigation methods are provided in the following subsections. All post-mitigation testing activities must be documented and reported to the agencies.

#### 4.3.1 SSD systems with sealing

- a. Leaks must be identified and fixed. With the depressurization system operating, smoke tubes are used to check for leaks through concrete cracks, floor joints, and at the suction point. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.
- b. Once a depressurization system is installed, its operation may compete with the proper venting of fireplaces, wood stoves and other combustion or vented appliances (e.g., furnaces, clothes dryers, and water heaters), resulting in the accumulation of exhaust gases in the building and the potential for carbon monoxide poisoning.



Therefore, in buildings with natural draft combustion appliances, the building must be tested for backdrafting of the appliances. If necessary, the backdrafting condition must be corrected before the depressurization system is placed in operation.

- c. The distance that a pressure change is induced in the sub-slab area (i.e., a pressure field extension test) must be conducted. Analogous to a communication test, this test is commonly conducted by operating the depressurization system and simultaneously observing the movement of smoke downward into small holes (e.g., 3/8 inch) drilled through the slab at sufficient locations to demonstrate that a vacuum is being created beneath the entire slab. A similar quantitative evaluation may also be performed by using a digital micromanometer or comparable instrument. If adequate depressurization is not occurring, the reason (e.g., improper fan operation) must be identified and corrected.
- d. Adequate operation of the warning device must be confirmed.
- e. At a minimum, post-mitigation indoor and outdoor air sampling must be conducted in buildings where pre-mitigation samples were collected and in buildings where physical data suggest possible impediments to comprehensive sub-slab communication of the depressurization system (i.e., locations with wet or oily sub-slab soils, multiple foundations and footings, minimal pressure differentials between the interior and sub-slab). Sampling locations, protocols and analytical methods should be consistent between pre-mitigation and post-mitigation sampling, where applicable.

Typically, post-mitigation sampling should be conducted 30 to 90 days after installing a depressurization system, but no sooner than 30 days after the system is in operation. If the system is installed outside of the heating season or at the end of a season, with the approval of the State, post-mitigation air sampling may be postponed until the heating season.

In cases of widespread mitigation due to vapor contamination and depending upon the basis of making decisions (e.g., a "blanket mitigation" approach within a specified area of documented vapor contamination [Section 3.3.1]), a representative number of buildings from an identified study area, rather than each building, may be sampled. Prior to implementation, this type of post-mitigation sampling approach must be approved by State agency personnel.

In newly constructed buildings, a site-specific and building-specific indoor air sampling plan is recommended due to potential interferences caused by the off-gassing of volatile chemicals in new building materials (e.g., paints, carpets, furniture, etc. [Section 1.4]). In these situations, if indoor air sampling is necessary, samples should be

- i. collected while the system is operational but before potentially interfering factors are brought into the building,
- ii. analyzed for a targeted list of volatile chemicals based on previous environmental sampling (e.g., groundwater, soil, soil vapor, etc.), and/or
- iii. collected while the system is operational but after potentially interfering factors have had an opportunity to off-gas.

If post-mitigation sampling results do not indicate a significant decrease in the concentrations of volatile chemicals previously believed to be present in the indoor air due to soil vapor intrusion, the reason (e.g., indoor or outdoor sources, improper

operation of the mitigation system, etc.) should be identified and corrected as necessary.

4.3.2 SMD systems with soil vapor retarder

- a. Leaks must be identified and fixed. With the depressurization system operating, smoke tubes are used to check for leaks in the membrane at seams, edge seals and at locations where the sheet was sealed around obstructions. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.
- b. Backdrafting conditions must be evaluated and, if necessary, corrected [Section 4.3.1].
- c. Adequate operation of the warning device must be confirmed.
- d. At a minimum, post-mitigation indoor and outdoor air testing must be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

4.3.3 HVAC modifications

- a. Check the building for positive pressure conditions (e.g., verify a pressure controller is maintaining the desired pressure differential and/or measure the pressure above the sub-slab by using field instruments).
- b. Backdrafting conditions must be evaluated and, if necessary, corrected [Section 4.3.1].
- c. Adequate operation of the warning device, if applicable, must be confirmed.
- d. Post-mitigation indoor and outdoor air testing must be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

4.3.4 Crawlspace ventilation and sealing

- a. Leaks must be identified and fixed. With the ventilation system operating, smoke tubes are used to check for leaks in openings and cracks in floors above the crawlspace that were sealed during installation of the system. Any leaks identified should be resealed until smoke is no longer observed flowing through the opening.
- b. Backdrafting conditions must be evaluated and, if necessary, corrected [Section 4.3.1].
- c. Adequate operation of the warning device, if applicable, must be confirmed.
- d. Post-mitigation indoor and outdoor air testing must be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

4.3.5 SVE systems designed to also mitigate exposures

- a. Backdrafting conditions must be evaluated and, if necessary, corrected [Section 4.3.1].
- b. The distance that a pressure change is induced in the sub-slab area must be conducted. This may be done by operating the SVE system and simultaneously observing the movement of smoke downward into small holes (e.g., 3/8 inch) drilled through the building's slab at sufficient locations to demonstrate that a vacuum is being created beneath the entire slab.

- c. Adequate operation of the warning device, if applicable, must be confirmed.
- d. Post-mitigation indoor and outdoor air testing must be conducted in buildings where pre-mitigation samples were collected [Section 4.3.1].

#### **4.4 Operation, maintenance and monitoring of mitigation systems**

When mitigation systems are implemented at a site, the operation, maintenance and monitoring (OM&M) protocols for the systems must be included in a site-specific OM&M plan. The party that installed the system is responsible for conducting OM&M activities and for developing the OM&M plan. Minimum requirements for OM&M activities associated with specific mitigation methods are provided in the following subsections. Also included is a discussion of non-routine maintenance. All routine and non-routine OM&M activities must be documented and reported to the agencies.

##### **4.4.1 SSD and SMD systems**

Routine maintenance should commence within 18 months after the system becomes operational, and should occur every 12 to 18 months thereafter. Based upon a demonstration of the system's reliability, a petition to alter the frequency may be submitted for the State's review. The frequency may only be altered after receiving approval from the State.

During routine maintenance, the following activities (at a minimum) must be conducted:

- a. a visual inspection of the complete system (e.g., vent fan, piping, warning device, labeling on systems, soil vapor retarder integrity, etc.),
- b. identification and repair of leaks [Sections 4.3.1 and 4.3.2], and
- c. inspection of the exhaust or discharge point to verify no air intakes have been located nearby.

As necessary, preventative maintenance (e.g., replacing vent fans), repairs and/or adjustments must be made to the system to ensure its continued effectiveness at mitigating exposures related to soil vapor intrusion. The need for preventative maintenance will depend upon the life expectancy and warranty for the specific part, as well as visual observations over time. The need for repairs and/or adjustments will depend upon the results of a specific activity compared to that obtained when system operations were initiated.

If significant changes are made to the system or when the system's performance is unacceptable, the system may need to be redesigned and restarted. Many, if not all, of the post-mitigation testing activities, as described in Sections 4.3.1 and/or 4.3.2, may need to be performed. The extent of activities required will primarily depend upon the reason for the changes and the documentation of sub-slab depressurization.

Generally, air monitoring is not required if the system has been installed properly and is maintaining a vacuum beneath the entire slab.

In addition to the routine OM&M activities described here, the building's owner and tenants are given information packages that explains the system's operation, maintenance and monitoring [Section 5.6]. Therefore, at any time during the system's operation, the building's owner or tenants may check that the system is operating properly.

#### 4.4.2 Other mitigation systems

For other mitigation systems (e.g., HVAC modifications, crawlspace ventilation, etc.), routine maintenance activities are generally comparable to post-mitigation testing activities [Section 4.3]. Activities typically include a visual inspection of the complete system, and identification and repair of leaks. System performance checks, such as air stream velocity measurements of ventilation systems, also should be performed.

As necessary, preventative maintenance (e.g., replacing filters, cleaning lines, etc.), repairs and/or adjustments must be made to the system to ensure its continued effectiveness at mitigating exposures related to soil vapor intrusion. If significant changes are made to the system or when the system's performance is unacceptable, the system may need to be redesigned and restarted [Section 4.4.1].

Air monitoring, such as periodic sub-slab vapor, indoor air and outdoor air sampling, may be needed to determine whether existing building conditions are maintaining the desired mitigation endpoint and to determine whether changes are needed. The type and frequency of monitoring is determined based upon a site-specific and building-specific conditions, taking into account applicable environmental data, building operating conditions, and the mitigation method employed.

#### 4.4.3 Non-routine maintenance

Non-routine maintenance may also be required during the operation of a mitigation system. Examples of such situations include the following:

- a. the building's owners or occupants report that the warning device indicates the mitigation system is not operating properly;
- b. the mitigation system becomes damaged; or
- c. the building has undergone renovations that may reduce the effectiveness of the mitigation system.

Activities conducted during non-routine maintenance visits will vary depending upon the reason for the visit. In general, building-related activities may include examining the building for structural or HVAC system changes, or other changes that may affect the performance of the depressurization system (e.g., new combustion appliances or deterioration of the concrete slab). Depressurization system-related activities may include examining the operation of the warning device and the vent fan, or the extent of sub-slab depressurization. Repairs or adjustments should be made to the system as appropriate. If necessary, the system should be redesigned and restarted [Section 4.4.1].

### **4.5 Termination of mitigation system operations**

Mitigation systems may not be turned off without prior approval from the State, except in emergency situations. Systems must remain in place and operational until they are no longer needed to address current or potential exposures related to soil vapor intrusion. This determination is based upon several factors, including the following:

- a. subsurface sources (e.g., groundwater, soil, etc.) of volatile chemical contamination in subsurface vapors have been remediated based upon an evaluation of appropriate post-remedial sampling results;
- b. residual contamination, if any, in subsurface vapors is not expected to affect indoor air quality significantly based upon soil vapor and/or sub-slab vapor sampling results;

- c. residual contamination, if any, in subsurface vapors is not affecting indoor air quality when active mitigation systems are turned off based upon indoor air, outdoor air and sub-slab vapor sampling results at a representative number of buildings; and
- d. there is no "rebound" effect that requires additional mitigation efforts observed when the mitigation system is turned off for prolonged periods of time. This determination is based upon indoor air, outdoor air and sub-slab vapor sampling from the building over a time period, which will depend upon site-specific conditions.

Given the prevalence of radon throughout the State of New York, consideration should be given to leaving the system in place and operating to address exposures related to radon intrusion after concurrence is reached that the system is no longer needed to mitigate exposures related to soil vapor intrusion. This action should be done only with permission of the property owner and after the property owner is aware of their responsibilities in operating, monitoring and maintaining the system for this specific purpose. If the property owner declines the offer, the system should be shut down and, if requested, removed in a timely manner.

#### **4.6 Annual certification and notification requirements**

Mitigation systems are considered engineering controls, defined as any physical barrier or method employed to

- 1. actively or passively contain, stabilize, or monitor hazardous waste or petroleum,
- 2. restrict the movement of hazardous waste or petroleum to ensure the long-term effectiveness of remedial actions, or
- 3. eliminate potential exposure pathways to hazardous waste or petroleum.

Therefore, depending upon the remedial program, submission of an annual certification to the State may be required. This certification must be prepared and submitted by a professional engineer or environmental professional acceptable to the State and affirm that the engineering controls are in place, are performing properly and remain effective. This requirement remains in effect until the State provides notification, in writing, that this certification is no longer needed.

If a property owner declines a mitigation system, the party responsible for arranging the design and installation the system must renew the offer on an annual basis, unless they demonstrate environmental conditions have changed such that a system is no longer needed.

## **Section 5: Community Outreach**

While community outreach is an essential component of the investigation and remediation of any site, it is particularly critical when evaluating soil vapor intrusion at a site due to the following:

- a. a heightened awareness by environmental professionals and the general public (both nationally and state-wide) for the importance of soil vapor intrusion;
- b. the relatively complicated nature of the exposure pathway (e.g., chemicals in groundwater or soil ending up in the indoor air of buildings versus contaminated groundwater entering the house through the use of a private well);
- c. the unknowns associated with the evolving science of investigating, evaluating, and mitigating exposures related to soil vapor intrusion; and
- d. the relatively complicated nature of mitigating the exposure pathway (e.g., the design, installation and operation of a sub-slab depressurization system in a home versus an immediate switch from using private well water to using bottled water).

When people have been or may be exposed to contamination, providing them with accurate and timely information about those exposures is extremely important. This information should include details about the types of chemicals, the levels of exposure, and possible health effects from those exposures. In addition, information should include details about the planning and progress of the investigation and remediation efforts. Techniques commonly used to inform the community about soil vapor intrusion issues are described in this section. The type, or types, of techniques selected for a site will vary depending upon the community's needs, site-specific conditions and program-specific requirements.

### **5.1 Site contact list**

A contact list contains names, addresses and telephone numbers of individuals and organizations with interest or involvement in a site. They may be affected by or interested in the site, or have information that staff need to make effective remedial decisions. Contact lists typically include residents near the site, elected officials, appropriate federal, state, and local government contacts, local media, organized environmental groups and the responsible party, as well as local businesses, civic and recreational groups, religious facilities, school district officials, and all staff (NYSDEC, NYSDOH, county health department, USEPA, etc.) involved in the site. The checklist provided in Appendix G.1 will help to identify who may need to be included in a particular site's contact list.

With respect to soil vapor intrusion, the site contact list is often used to

- a. send a fact sheet announcing a proposed investigation in the area, a major project decision or proposal, the project's status or progress, a public meeting or availability session, or the availability of documents in the repositories;
- b. contact building owners and tenants to arrange sampling dates and times and to transmit sampling results (in written form and/or verbally); and
- c. provide community members with verbal updates on the project's status or progress.

The member of the project team (defined as the NYSDEC, NYSDOH, responsible party, etc.) that develops and maintains the site contact list is determined on a site-specific and/or program-specific basis. Development and revision of the contact list are ongoing activities throughout the site's investigation and remediation. Guidance on how to create a site contact list is provided in Appendix G.1.

## 5.2 Project staff contact sheet

As implied by the name, this is a summary of the contact information for staff working on the site that can be handed out to the community. Often included on the sheet are the name, title, affiliation, role or area of expertise, address, telephone number, email address, facsimile number for each staff member. The contact sheet provides the community with a quick reference on whom to call with questions, comments or concerns about the site. Project staff may also use the site contact sheet to direct inquiries to the most appropriate person. This is particularly useful when there are many agencies working on the site and many issues, such as site investigation, health studies, medical outreach, etc., being addressed.

The site contact sheet should be handed out at public meetings or availability sessions, when door-to-door visits and sampling are conducted, and in conjunction with other appropriate outreach activities. The sheet should be developed early on in the process and kept up-to-date. The member of the project team that develops and maintains the staff contact sheet is determined on a site-specific and/or program-specific basis.

## 5.3 Fact sheets

A fact sheet is a written summary of important information about a site. It presents information in clear and concise terms for the community. Fact sheets aid consistent distribution of information and citizens' understanding of significant issues associated with site-related activities. With respect to soil vapor intrusion, fact sheets are often used to

- a. announce a proposed soil vapor intrusion investigation in the area, either as a stand-alone activity or in conjunction with the site's overall investigation;
- b. summarize the results of an investigation and the anticipated next steps in the process;
- c. invite the public to a meeting or availability session to discuss the proposed investigation, the results of a recently completed investigation, the anticipated next steps, etc.; and
- d. provide additional information on topics associated with soil vapor intrusion, such as specific air guidelines for volatile chemicals.

The member of the project team that plans, develops and distributes the fact sheet is determined on a site-specific and/or program-specific basis. Factors to consider when designating the lead include the site's remedial program, the expected content of the fact sheet, and the relationship of various team members with the community. For example, if the community strongly distrusts the responsible party and wants to know how the state is determining that their actions are appropriate, the state should be the lead. A combination of team members may also be suitable.

All team members must be included in reviewing and finalizing the fact sheet. Once the state approves the fact sheet, it may be released to the public. Timely distribution of the fact sheet is important. Sufficient time should be allowed in the development and review schedule to ensure that the fact sheet is distributed — *and that it is received* — before the critical activity takes place. Specific timeframes for release include the following:

- a. 2 weeks prior to a public meeting or availability session, or commencement of field activities;
- b. within 24 hours of receiving a specific request for an available fact sheet from the community (e.g., members of the community that did not receive a copy of the fact sheet in the mail);

- c. if applicable, before a comment period begins (otherwise a 30-day comment period becomes, in reality, a 25-day comment period); and
- d. if appropriate, concurrently with letters to the community explaining sampling results.

Copies of fact sheets commonly used to supplement discussions related to soil vapor intrusion are provided in Appendix H. Additional guidance on how to plan, develop and distribute fact sheets is provided in Appendix G.2.

#### 5.4 Public gatherings

The following are several types of public gatherings where project staff can meet with the community:

- a. Traditional Public Meetings: Project staff generally present information and answer questions. Citizens are encouraged to ask questions and provide comments;
- b. Public Availability Sessions: The session is held in a casual setting, without a formal agenda and presentation. Staff generally conduct an availability session about a specific aspect of a site, which it publicizes ahead of time. The format promotes detailed individual or small group discussion between staff and the public. An availability session may be targeted to a specific subgroup of the overall community. For example, a session may be held where project staff meet with building owners and tenants to discuss their individual sampling results;
- c. Public Forum: The forum is held in a casual setting, without a formal presentation. Typically, the format is one of "question and answer" — a panel of project staff (or, if applicable, outside experts) answer questions asked by community members in an open discussion; and
- d. Other: Project staff may be invited to give presentations or to make themselves available for questions at community group meetings, such as community or neighborhood board meetings, school board meetings, etc.

If necessary, a combination of the above may be used. The type, or combination of types, of gathering (if any) selected should be decided based on site-specific, program requirements and community-specific conditions, such as the following:

- a. Is the investigation limited to on-site buildings, to a localized area of off-site buildings, or to the off-site neighborhood surrounding the site?;
- b. Is the soil vapor investigation being performed as part of ongoing site investigation activities (and consequently ongoing outreach activities), or is this issue being revisited at a site where remediation was considered "complete?";
- c. What type of outreach has the community favored in the past?;
- d. What are the objectives of the meeting? Can one meeting type accomplish each of the objectives or are different meeting types needed on successive days (e.g., public meeting followed by an availability session)?; and
- e. Who is the desired audience? Should the meeting be held in the afternoon to accommodate an elderly population and repeated in the evening for people who work during normal business hours?

The member of the project team that coordinates and implements the gathering is determined on a site-specific and/or program-specific basis. Factors to consider when designating the lead include the site's remedial program, the expected subject of the meeting, and the relationship of various team members with the community. A combination of team members may also be appropriate.



Additional guidance on how to plan and conduct a public meeting and an availability session is provided in Appendices G.3 and G.4.

### 5.5 Letters transmitting results

When indoor air and/or sub-slab vapor samples are collected from within or beneath a building, a letter providing the sampling results and the conclusions drawn from the data evaluation must be transmitted to the building's owner. If the building is a rental property, the transmittal letter must be sent to the tenants residing in the areas where the samples were collected and a copy to the property owner/landlord.

A transmittal letter must include the following:

- a. the address of the building sampled;
- b. the date samples were collected;
- c. the type of samples collected (e.g., sub-slab vapor, indoor air and outdoor air);
- d. indoor air sampling locations (e.g., basement, crawlspace, first floor living room, etc.);
- e. who collected the samples (e.g., the state, or [Consultant Name] on behalf of [Responsible Party name], etc.);
- f. why samples were collected (e.g., to evaluate the potential for exposures associated with soil vapor intrusion);
- g. the site name and number (usually included in the subject line);
- h. the compound(s) or group of compounds of concern (e.g., trichloroethene or volatile organic compounds);
- i. an overview of the sampling results (e.g., a table summarizing compounds detected in each sample and/or a figure illustrating sampling locations and corresponding results);
- j. copies of the laboratory sheets for each sample collected and the completed building questionnaire/inventory;
- k. a statement of the conclusions drawn and the next steps (e.g., soil vapor intrusion appears to be the likely source of volatile chemicals in your indoor air and we would like to install a sub-slab depressurization system to minimize exposures);
- l. if applicable, what information should be shared with employees and/or patrons of the facility (e.g., the transmittal letter and enclosed fact sheets, a situation-specific fact sheet and cover memorandum, etc.);
- m. contact information for project staff; and
- n. fact sheets that supplement information provided in the letter.

The member of the project team that transmits the letter is typically the member that conducted the investigation. A representative of each member is copied on each transmittal. For example, for investigations conducted by the state, letters are transmitted by the NYSDOH; state and local agencies, as well as a representative for the responsible party (or other non-agency project staff), are copied. For investigations conducted by the responsible party, the responsible party transmits letters that have been reviewed and approved by the state, and copies state and local agency representatives.

The level of detail provided in the letter will depend upon who transmits the letter. For example, letters written by the NYSDOH may recommend actions to reduce exposures to indoor sources (i.e., not site-related sources) of volatile chemicals, or address expected risks associated with an identified exposure. Letters transmitted by a responsible party

generally focus on site-related contamination and their identified next steps. These letters generally refer the recipients to the state for questions regarding non-site-related compounds and health concerns. For additional guidance on the content of the transmittal letters, contact the NYSDOH's Bureau of Environmental Exposure Investigation at 1-800-458-1158, extension 27850.

Timely distribution of the transmittal letter is important. Generally, final (i.e., verified) sampling results from the laboratory are available 6 to 8 weeks after the samples are submitted. As soon as they are available, final results should be forwarded to the team member that is transmitting them. Sufficient time should be allowed in the development and review schedule to ensure that the letter is transmitted within 2 weeks after final results are available.

If there is significant community interest in the sampling results, reasonable attempts must be made to inform the building owners and tenants of their results verbally in addition to sending a transmittal letter. Other interested community members, such as residents, press and elected officials, may be given an overview of the investigation results and the conclusions drawn *after* each building owner and tenant has been notified.

## **5.6 Soil vapor intrusion mitigation information**

Once a mitigation system (e.g., sub-slab depressurization system) is installed in a building, an information package must be given to the building's owner and tenants, if applicable, to facilitate their understanding of the system's operation, maintenance and monitoring. This package must include the following:

- a. a description of the mitigation system installed and its basic operating principles;
- b. how the owner or tenant can check that the system is operating properly;
- c. how the system will be maintained and monitored and by whom;
- d. a list of appropriate actions for the owner or tenant to take if the system's warning device (e.g., pressure gauge, alarm, etc.) indicates system degradation or failure; and
- e. contact information (e.g., names, telephone numbers, etc.) if the owner or tenant has questions, comments or concerns.

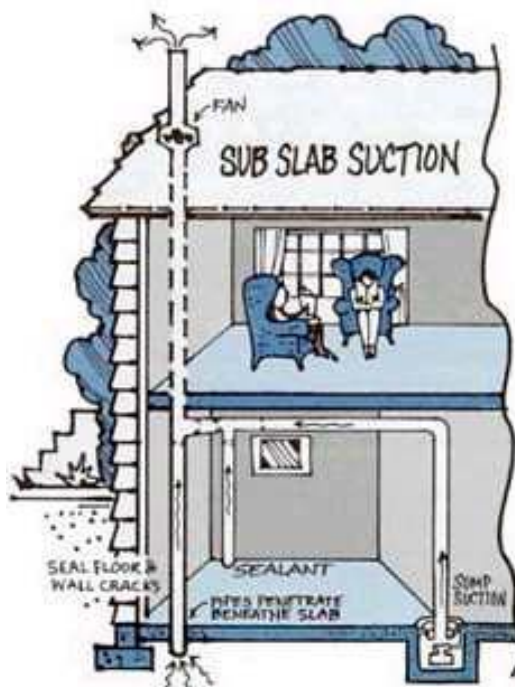
The building's owner should also receive the following information:

- a. any building permits required by local codes;
- b. copies of contracts and warranties; and
- c. a description of the proper operating procedures of any mechanical or electrical system installed, including manufacturer's operation and maintenance instructions and warranties.

Wherever possible, illustrations should be provided. For example, pictures of a manometer under normal operating conditions [Figure 5.1], as well as drawings or schematics showing the system at work [Figure 5.2].



**Figure 5.1**  
Manometer indicating the SSD system is operating properly.



**Figure 5.2**  
Example of an illustration showing how a SSD system works.  
[Source: USEPA, EPA 402-K-00-008, July 2000.]

The member of the project team who provides this information is the member who installed the mitigation system.

### 5.7 Toll-free "800" numbers

Toll-free information numbers provide quick, easy access for people who have questions, comments or concerns about a site. At a minimum, the NYSDOH site project manager's name and the following "800" number must be shared with the community in fact sheets and transmittal letters, at public gatherings, when samples are collected, and with other outreach techniques for their use if they have health-related questions, concerns or comments related to soil vapor intrusion at the site.

**NYSDOH**  
Center for Environmental Health  
Bureau of Environmental Exposure Investigation  
Toll-free Information Line  
  
1-800-458-1158, ext. 27850

Note: The "800" number is an *information* line — not a "*hotline*" — because callers may not receive immediate response, such as on nights or weekends.

Similarly, applicable toll-free numbers setup and maintained by other project team members should also be shared with the community whenever appropriate. Additional information on the use of toll-free "800" numbers as an outreach tool is provided in Appendix G.5.

### **5.8 Door-to-door visits**

Door-to-door visits involve gathering or distributing site information by meeting individuals at their residences or businesses. Typically, this outreach technique is used to supplement other communication, such as telephone calls and letters. With respect to soil vapor intrusion, project staff may visit residents near a site to provide information, answer questions, or obtain permission for activities on private properties. All team members must be aware of the specifics of the door-to-door visits (e.g., who will be conducting the visits, the reason, the dates, etc.).

Additional information on conducting door-to-door visits is provided in Appendix G.6.

### **5.9 Document repositories**

A document repository is a collection of documents and other information developed during the investigation and remediation of a site. It is located in a convenient, public facility, such as a library, so that affected and interested members of the public can easily access and review important information about the site. A repository is maintained through the site's operation and maintenance phase, or until its release from the applicable remedial program.

A site document repository helps the public review

- a. documents about which the state is seeking public comment;
- b. studies, reports and other information; and
- c. complete versions of documents summarized in fact sheets, meeting presentations or media releases (summaries should note the locations of local repositories where the complete documents are available).

The member of the project team that establishes and maintains the document repository is determined on a site-specific and/or program-specific basis. Additional guidance on how to establish and maintain a document repository is provided in Appendix G.7.

### **5.10 Medical community outreach**

Outreach to the medical community is an activity or combination of activities undertaken to assist local health care providers in caring for people who have concerns about site-specific environmental exposures. The goal of this type of outreach is to assist the individual provider by giving him/her much of the site-specific information related to the contaminants and to provide information about the site itself. This type of outreach is undertaken whenever the NYSDOH and/or other health agencies determine that the site-specific contaminants may be unfamiliar to the local medical community. Conversely, this outreach can be undertaken when community members express the concern that their health care providers may be unfamiliar with potential adverse health effects related to contaminants at the site.

The targeted audience for this type of outreach consists of specific groups of health care providers most likely to treat people with concerns about potential environmental exposures. Some examples of targeted groups of specialists could include any combination of the following: Family Practice, Internal Medicine, Preventive Medicine, Oncology,

Neurology, Allergy, Pediatrics, Obstetrics, Dermatology and Emergency Medicine. Likewise, materials can be sent to medical and nursing schools, residency programs, and medical libraries if they are located nearby. Developing the targeted list of health-care providers is a cooperative effort between local and state departments of health, with input from the community as well.

The NYSDOH, in partnership with the Agency for Toxic Substance and Disease Registry (ATSDR) and the local health department, can conduct these activities, which could include any one or a combination of the following:

- a. announcements made at public meetings that the NYSDOH Center for Environmental Health will mail out information packets to individual physicians at the request of any concerned citizen;
- b. an article placed in a local newspaper, or, if applicable, in a newsletter periodically sent to residents, stating that the NYSDOH Center for Environmental Health will mail out packets to individual physicians at the request of any concerned citizen. The NYSDOH "800" number and two NYSDOH contact names would be given;
- c. an article submitted to the newsletter of the local county medical society, stating that the NYSDOH and the ATSDR have information to help providers with questions about site-related contamination in the area of the site. The NYSDOH "800" number and two NYSDOH contact names would be given; and
- d. materials sent to medical and nursing schools, residency programs, and medical libraries if they are located nearby.

Local and state departments of health, and ATSDR, have developed appropriate outreach materials. The information packets should contain a letter to the physician, site-specific fact sheets, brochures, and booklets about potential exposures and about the contaminants in the area of the site. As an example, here is a list of fact sheets and pamphlets that an information packet for a site with PCE and TCE as contaminants of concern might contain:

- a. a letter of explanation to the provider, including the NYSDOH "800" number to call for access to more information, as well as two NYSDOH contacts with whom to speak initially;
- b. a site-specific fact sheet written for the community, explaining various site-related issues;
- c. a compact disc of ATSDR case studies in environmental medicine (CSEMs), with opportunities for earning many free continuing medical education (CME) credits through the Centers for Disease Control and Prevention;
- d. a hard copy of both the "Trichloroethylene (TCE) Toxicity" and "Taking an Environmental Exposure History" case studies;
- e. two small "quick reference guides" produced by ATSDR about evaluating environmental exposures and doing an exposure history;
- f. a NYSDOH fact sheet on Trichloroethene (TCE) in indoor and outdoor air;
- g. an ATSDR fact sheet on Trichloroethylene (TCE);
- h. a NYSDOH fact sheet on Tetrachloroethene (PERC) in indoor and outdoor air; and
- i. an ATSDR fact sheet on Tetrachloroethylene (PERC).

For additional information on this outreach tool, please contact the NYSDOH Center for Environmental Health's Outreach and Education Unit at 1-800-458-1158, extension 27530.

## References

Kladder, D. L, J. F. Burkhart, and S. R. Jelinek. "Protecting Your Home from Radon: A Step-by-step Manual for Radon Reduction." 1993.

New York State Department of Environmental Conservation. "Citizen Participation in New York's Hazardous Waste Site Remediation Program: A Guidebook." June 1998.

United State Environmental Protection Agency. "Model Standards and Techniques for Control of Radon in New Residential Buildings" (EPA 402-R-94-009; March 1994).

United State Environmental Protection Agency. "Radon Mitigation Standards" (EPA 402-R-93-078; revised April 1994).

United State Environmental Protection Agency. "Consumer's Guide to Radon Reduction" (EPA 402-K-03-002; revised February 2003).

United States Environmental Protection Agency. "Home Buyer's and Seller's Guide to Radon" (EPA 402-K-00-008, July 2000).